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SCIENTIFIC AMERICAN SUPPLEMENT. No. 1208

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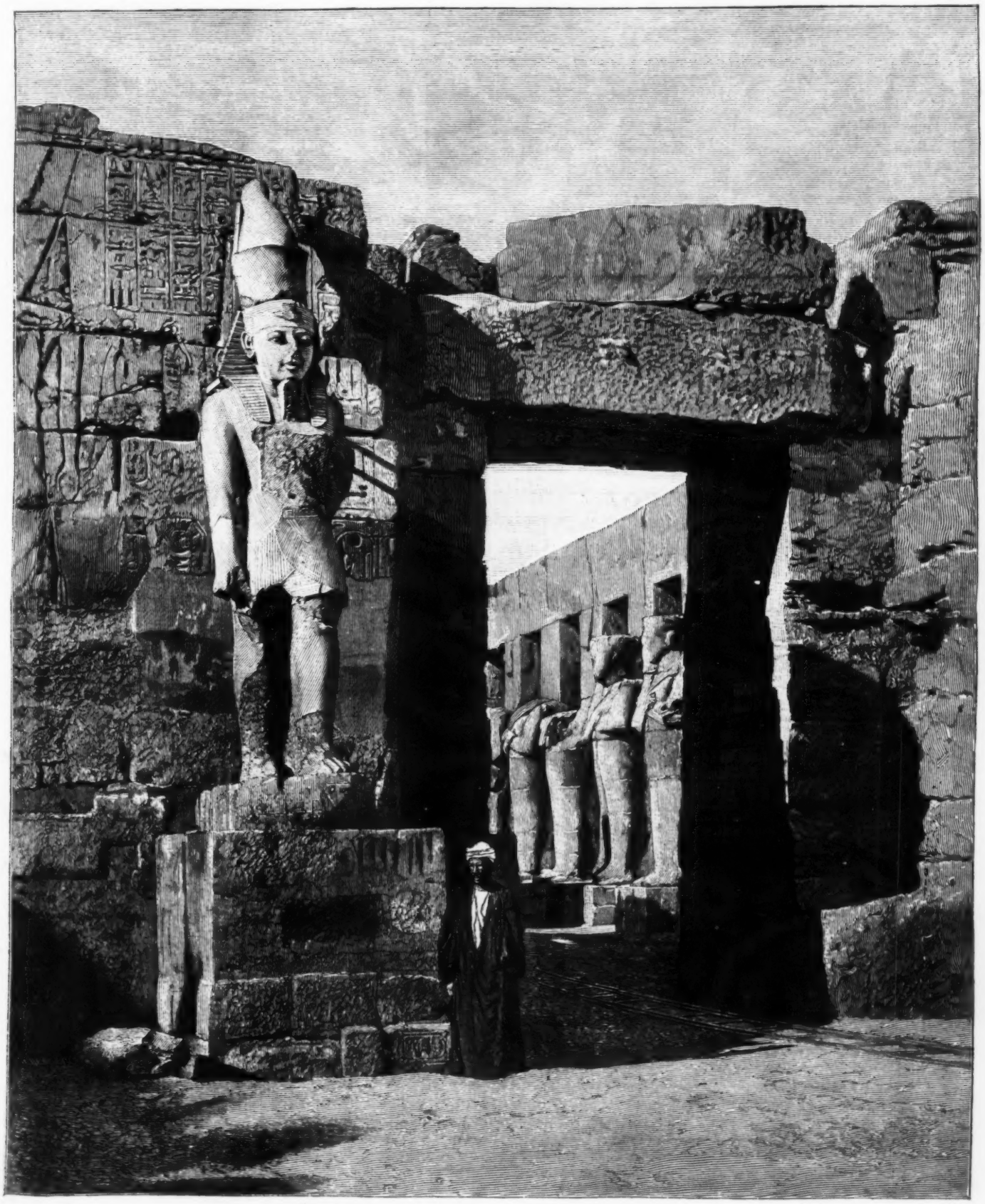
Scientific American, established 1845.
Scientific American Supplement, Vol. XLVII, No. 1208. NEW YORK, FEBRUARY 25, 1899. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

RESTORATION OF THE TEMPLE OF KARNAK.

OF Thebes, the city of a hundred gates, which under the kings from the eleventh to the twentieth dynasty made a glorious display of its palaces and temples upon the two shores of the Nile, nothing now remains but ruins, and these, as Wilkinson has said, are the vastest and most splendid of ancient or modern times. Devastated by the Persians under Cambyses, by the Arabs, by the Christians of Egypt, and by the fellahs, and partially demolished by repeated earthquakes and inundations, its principal structures have, nevertheless, weathered all storms, and we now see the sphinxes and colonnades rising from the earth like specters of another age that have come to bear witness to the grandeur and power of a vanished civilization.

Let us, in a word, recall these celebrated ruins, which



STATUE OF RAMESES III. AS IT NOW APPEARS IN FRONT OF THE TEMPLE AT KARNAK.

are well known to all travelers, and are, as has been said, worth a trip to Egypt to see. Upon the right bank of the Nile there are two groups of edifices—Karnak and Luxor; and upon the left bank, Gournah, Ramesseum, and Medinet-Abou. Some structures of less importance gravitate around these majestic groups and make of the vast plain upon which Thebes stood a sort of cemetery of granite colossi.

We propose to occupy ourselves only with the largest group of such structures, that of Karnak, at which important work has been in progress for the last three years under the direction of M. Georges Legrain, inspector of the service of Egyptian antiquities.

Before giving a summary of the work that has been done, a few explanations seem to us to be necessary.

The great temple of Karnak was erected in honor of Ammon, the generating god. To take it from the beginning (and for this we must go back to the fantastic date of 24,000 years before Christ), the first sanctuary was nothing but the house of God founded by Osirtasen I. It became to the Egyptians what the temple of Delphi was to the Greeks—the national monument; and all the sovereigns of all the dynasties that succeeded each other in power had but one aim, and that was to stamp it with their seal by embellishments and new structures, the grandeur of which should eclipse the work of their predecessors. Thothmes III., for example, erected those obelisks which are marvels of gracefulness, and covered the walls of the temples with bass-reliefs; and his successor erected pylones, built a palace, reconstructed the primitive sanctuary of granite, and constructed the celebrated "Promenade."

Under the Ramessides there was still more done. The hypostyle hall (that is to say, the entire hall of which the ceiling is supported by columns), a huge colonnade which seems to have been erected by Titans, is the work of Rameses I., of Seti I., of Rameses II., and of Rameses III. (1800 years B. C.)

In order to complete the edifice it would have been necessary to construct a new sanctuary, some pylones, and a court with porticoes. The successors of Rameses III. dared not undertake anything.

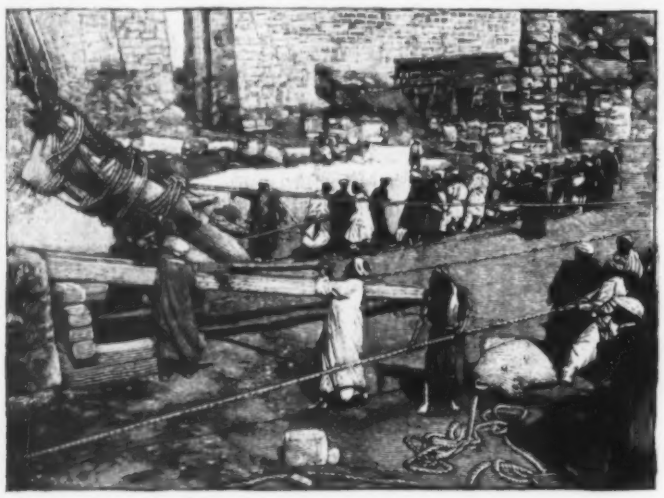
The hypostyle hall was entirely covered. One of the windows through which it was lighted is still to be seen. Properly speaking, it was not a temple, but a place of reunion of solemn assemblies.

Three centuries later, the last Pharaohs endeavored in vain to surpass this inimitable masterpiece; but their work, consisting of a new hypostyle hall, remained unfinished. Eight columns only rose in space, surmounted with unfinished porticoes.

Up to 1895 the temple remained two-thirds buried beneath a mass of debris accumulated through time and man.

Marietta himself, an archæologist of ability, who discovered the Serapeum, did not believe it possible to save the temple, and wrote: "The temple of Karnak has, more than any other, undergone the injuries of time through the negligence of its builders, and especially through its position with respect to the Nile. Since the same causes produce the same effects, we may foresee a time when, through continual caving, the magnificent hypostyle hall, for example, will see the base of its columns, already corroded three-quarters of the way up, yield under a last effort, and the columns will fall as have fallen those of the West Court."

In three years, and by very simple means, M. G. Legrain has cleared the great West Court; cleared and restored the temple of Rameses III., and raised and put in place its colossi; cleared and restored the palace of Thothmes III., as well as the celebrated "Promenade" and what is called the "Botanical Garden" (hieroglyphics faithfully representing the animals and plants brought by Thothmes from Syria); and cleared away the rubbish and discovered an alley of superb criocephalous sphinxes ending at an ancient quay bearing the marks of the high waters of the Nile from the year 960 to the year 647 before Christ.



SETTING UP THE STATUE OF RAMESES III.

THE STATUE OF RAMESES III.

After having likewise cleared out the center of the hypostyle hall, he is now undertaking the complete restoration of its 134 columns, which are 75 and 59 feet in height and 10½ and 8½ feet in diameter. One of these, well known by the name of the "Leaning Column," was threatened with immediate ruin, and its fall promised to endanger the existence of the entire hall.

By means of filling in and an inclined plane, M. Legrain succeeded in lowering, piece by piece, its architraves of a weight of 57,200 pounds, and its capital and its tambours of 22,000 and 9,900 pounds.

Seven hundred fellahs are employed in the work.

COLUMN OF TARAGA, COURT AND COLOSSI OF THE TEMPLE OF RAMESES III., AFTER RESTORATION.

The complete restoration of the hypostyle hall will cost no more than 125,000 francs. It will take about ten years to restore the entire temple.

Although modern Egypt has escaped our influence, and that to a great extent through our own fault, ancient Egypt remains and will remain French, since it is to Frenchmen that she owes her renaissance after a burial twenty times secular in which the ruins of her edifices have been wasting away. Since the Egyptian

INTERIOR OF THE PROMENADE OF THOTHMES III. AFTER BEING FREED FROM RUBBISH.

expedition, which, so to speak, revealed these to the world, it is to Champollion, Marietta, and Maspero that is due the honor of all the discoveries and the measures taken for the preservation of what remains.

The Nile, up to that time, had been Karnak's greatest enemy; and the great inundation of 1887 submerged the hypostyle hall under ten feet of water. It was the Nile itself that was forced to repair the damage that it had done. Its water, diverted by a small canal, again came to lave the columns and pylones, and to dissolve the calcareous deposits that were corroding them at a point flush with the ground.

The work of consolidation and excavation was afterward undertaken; and it is a curious fact that the fellahs merely began again exactly what their fathers had done in order to crown with success the work to be accomplished. In looking at these inclined planes and at these theoretical laborers bent under baskets of earth, we find ourselves carried back several thousand years, since we have seen the same picture sculptured upon the walls of the edifices, in commemoration of their construction. There is but one thing wanting in the modern picture, and we have not to regret it, and that is the man with the lash, the taskmaster of the force of laborers of what was, of old, the land of the Pharaohs.

For the above particulars and the engravings we are indebted to L'Illustration.

A YEAR ON CHRISTMAS ISLAND.

AT a meeting of the Royal Geographical Society, held at the University of London, in November last, Mr. Charles W. Andrews, F. G.S., assistant in the Natural History Department of the British Museum, read a paper describing Christmas Island. Mr. Andrews observed that one of the most interesting of the lonely islets of the Indian Ocean was Christmas Island. The seas around it were of enormous depth, and soundings of over 1,000 fathoms occurred within two or three miles of its coasts. The first mention of the island occurred in a map by Pieter Goos, published in Holland in 1666, in which it was called Moni. In subsequent maps, this name and that of Christmas Island were applied to it indifferently, but it was not known by whom the island was discovered and named.

THE FIRST ATTEMPT

at an exploration of the island was made by the frigate "Amethyst," from which a boat's crew was landed with the object of attempting to reach the summit; but the island cliffs proved an insuperable obstacle, and the ascent was abandoned. In 1881 the surveying vessel "Flying Fish" (Captain Macclear) was ordered to make an examination of the island. The coast was found to consist of steep limestone cliffs, and it was only after sailing nearly all round the island that an anchorage was found in a bay with a white shingle beach on the north coast; to this the name Flying Fish Cove was given, and it is now the site of a small settlement. In the following year Her Majesty's ship "Egeria" called at the island and remained about ten days. Mr. J. J. Lister accompanied the expedition as naturalist, and made extensive collections both of the fauna and flora, but had not time to penetrate to the middle of the island. In 1890 Her Majesty's ship "Redpole" called at the island for a few hours, and Mr. H. N. Ridley, of the Singapore Botanical Gardens, who was on board, collected a number of plants not previously recorded, and has written an interesting account of his visit. It seemed desirable, however, that

A MORE COMPLETE EXAMINATION

of the island should be undertaken, and, if possible, collections should be made at different seasons of the year, and in 1896 Sir John Murray generously offered to pay the expenses of such an expedition. He (Mr. Andrews) was fortunate enough to be able to avail himself of that offer, and, the trustees of the British Museum having granted the necessary leave of absence, he left England at the beginning of May, 1897. The greatest length of the island, from Northeast Point to Egeria Point, was about twelve miles. The greatest width from north to south was about 9 miles; the least 3½ miles. Its area might be roughly stated as 43 square miles. The island consisted of a central plateau, highest toward the north and east, descending to the sea on all sides by a succession of terraces separated by slopes or cliffs. Along the raised rim of the plateau there were a number of hills, the highest of which (Murray Hill) occurred toward Northwest Point; its height was about 1,170 feet. The summit was formed by masses of dolomitic limestone, and on its lower slopes there were beds of shelly limestone and a peculiar deposit which seemed to be mainly made up of tiny spherules of altered volcanic glass. Over Northeast Point was an elevation (Phosphate Hill) which, though not so high (900 feet), was particularly interesting on account of the extensive deposit of phosphate of lime which was found there. This substance was strewn over the surface in blocks of all sizes, and in some places it was found to a considerable depth; in others, however, it could be seen to rest directly on an irregular surface of the dolomitic limestone, occasional pinnacles of which projected through it. At the northern end of the hill the phosphate was found on both upper and inner slopes; but further south on the plateau side only, the outer being occupied by a reef of limestone, which descended to the terrace beneath in a low cliff. The area actually covered by this thick deposit of phosphate of lime was about half a mile long by a quarter broad; but an immense quantity occurred in the form of irregular nodules and blocks scattered over the slopes and terraces of that part of the island. There were other less extensive beds over Flying Fish Cove, and also at several points along the eastern edge of the plateau. Probably when the islands were still low and not covered with frost they formed the homes of

MYRIADS OF SEA BIRDS,

and the guano thus formed, after undergoing alteration, mainly through loss of its organic matter, gave rise to the hard, phosphatic rock now existing. At the same time the limestones on which it rested had often been phosphatized, and lumps of coral, consisting mainly of phosphate of lime, were sometimes found. The extensive accumulations of guano which must have taken place pointed to a time when the rainfall must have been much less than at the present day, a condition which might, at least in part, have been dependent on the circumstances that the islands were low and probably

INTERIOR OF THE PROMENADE OF THOTHMES III. BEFORE EXCAVATION.

A ROW OF CRIOCEPHALOUS SPHINXES.

free from forest. The history of the island, as far as it could be made out, seemed to have been as follows: At first, at no great depth, there was a submarine bank upon which numerous foraminifera, including orbitoides, lived, and the shells of which formed thick beds of limestone. The foundation of this bank was volcanic, and from time to time lava, at first trachytic, was erupted through and upon the limestones; the occurrence of thick bands of palagonite tuff indicates that the eruptions were submarine. Some elevation took place, and the beds of tuff became consolidated by the infiltration of lime. In the next place, the whole was covered with thick beds of white limestone crowded with large orbitoides. These strata seemed to have overlapped the edges of the beds of tuff, and in places it could be seen that they dipped away from the central mass. The deposits resting on the orbitoidal limestones were for the most part covered with recent accumulations, but they appeared to have been mainly foraminiferal limestones. Upon the foundation thus prepared extensive reefs grew up and formed an atoll-shaped group of islands, the reef-flat and islands being now represented by the raised rim of the plateau and the hills rising from it, the lagoon by the central plateau itself.

THE CLIMATE OF CHRISTMAS ISLAND

was a delightful one, and during the greater part of the year resembles a very hot English summer tempered with sea breezes. The maximum temperature recorded during his stay was 80° Fah., on November 20, the minimum, 70° Fah., on February 13, when it was raining heavily. The greatest range of temperature in twenty-four hours was 14°. The average maximum and minimum might be taken as about 84° Fah. and 75° Fah., respectively, the former occurring an hour or two after midday, the latter shortly before sunrise. The prevailing wind was the southeast trade, which blew about 300 days in the year. Very heavy dews kept the vegetation fresh, even after a long spell of dry weather. The island was perfectly healthy, there being no marshes or stagnant pools, while on the other hand there was a fair supply of good water. The whole island was covered with forest, except the spray-swept edges of the sea cliff and the vertical faces of the inland ones. Near the sea there was usually a belt of thick low forest of iron woods, nyamploos, waroo, etc., mingled with pandanus, which in places formed impenetrable jungles. Outside this the cliff usually had a scanty covering of coarse grass and clumps of bushes. Within it, on the other hand, the rich phosphatic soil supported a thick forest of lofty trees. One of the most remarkable of these was a species of Gyrocarpus, or

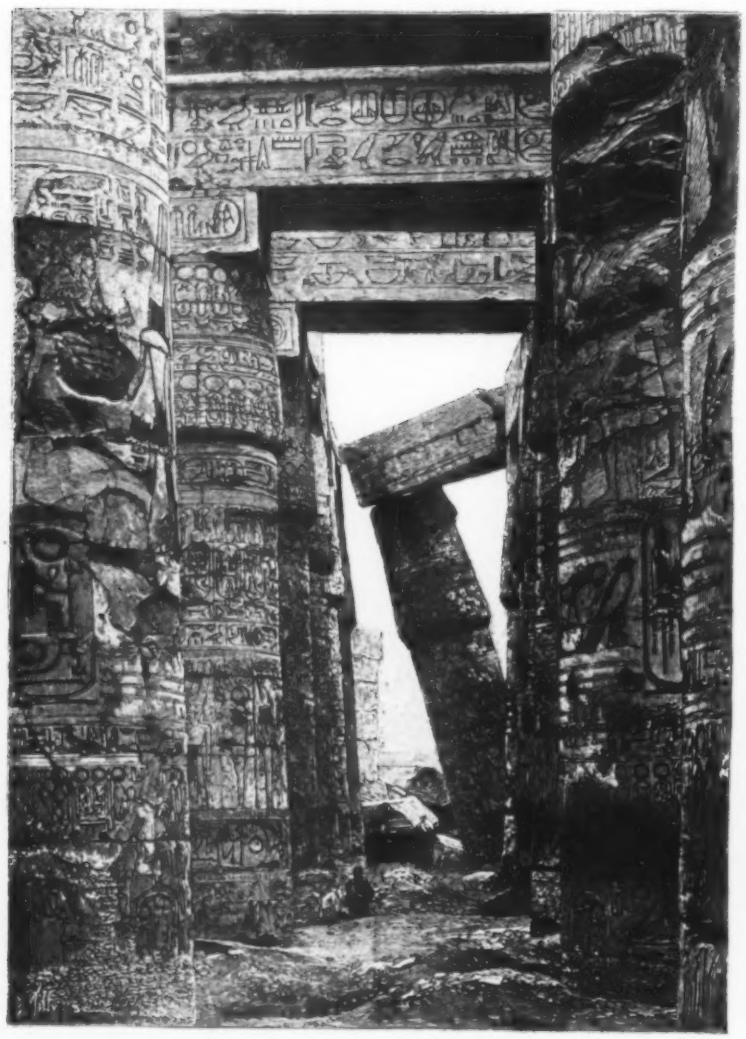
WINGED FRUIT TREE,

to give a translation of the native name, the fruits of which had two membraneous expansions, something like those of the fruits of the ash, by means of which they were carried long distances; except during the rainy season this tree was completely destitute of leaves, and since it was very common, it gave a very peculiar aspect to the forest near the coast. Other notable trees were the Boognor, the timber of which was extremely good, and had been called teak; the buttress tree, round the base of which buttress-like outgrowths occurred sometimes 10 feet high by 15 feet or 20 feet long, and not more than 2 inches or 3 inches thick—many of the other trees had buttress-like supports, but in none were they developed to that extent; the stinking wood tree, the peculiarity of which was perhaps sufficiently explained by its name; and the wild sago palm. The last was peculiar to the island, and was valuable on account of the excellent sago that it supplied. In favorable localities it might reach a height of from 60 feet to 70 feet. As must be expected in an oceanic island, the fauna was not a rich one. There were only five species of mammals, consisting of two kinds of rats, a shrew mouse, and two bats. The presence of the rats and shrew must be accounted for by supposing that they were drifted to the island on floating wood, while the bats reached the island by flight. Owing to the abundance of food and absence of enemies, the rats swarmed everywhere. At nightfall they appear in troops. They ate nearly everything that could be eaten, and were particularly destructive to the fruits and vegetables that are now being cultivated. A reddish-brown species was by far the most numerous; it was an expert climber, and he had seen it run up the trailing bushropes like a squirrel. The second species was black, with thick, coarse fur; it was a comparatively sluggish animal, and lived in burrows in small colonies. Both species were peculiar to the island. Of the bats, one was a small insectivorous species, the other a large fruit bat. The latter was very common, and was a great nuisance, both on account of the quantities of fruit, especially papaias, that it destroyed, and also because of the noise it made, its cry being a horribly harsh scream, apparently uttered during both the inspiration and expiration of its breath.

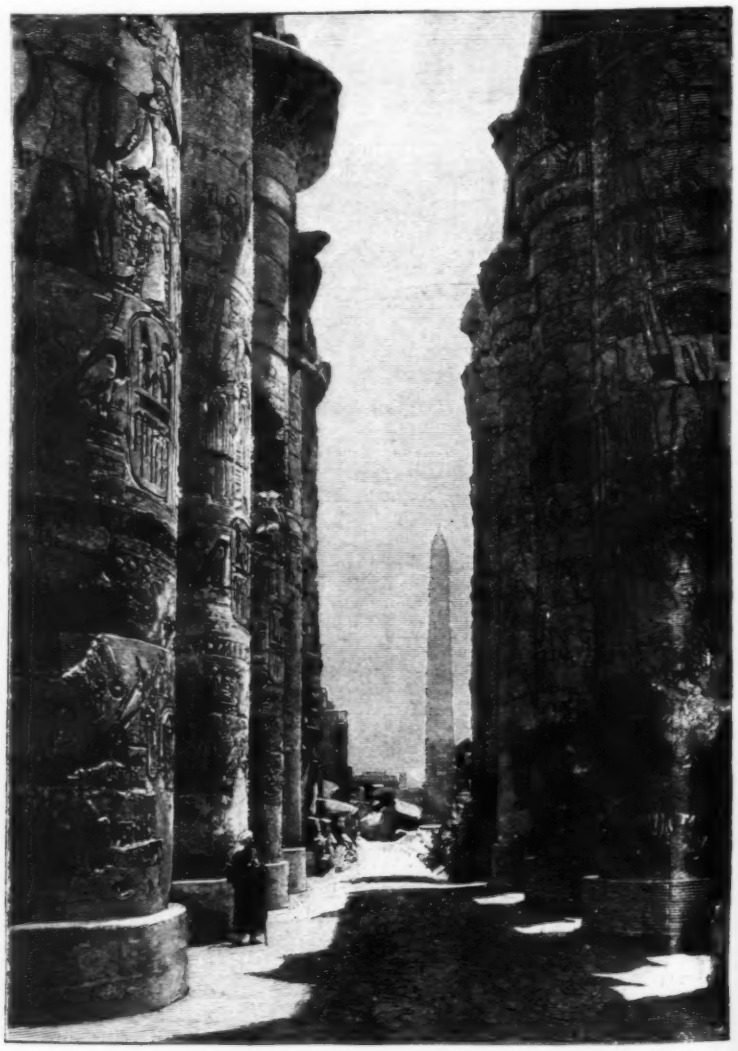
ONE REMARKABLE PECULIARITY

was that this bat had, to a great extent, abandoned nocturnal habits, and several might often be seen circling about high in the air in the bright hot sunlight, sometimes even in the middle of the day. It was found only in Christmas Island. The land birds, except the birds of passage and a small rail, were all peculiar to the island. They include two kinds of pigeon, a hawk, an owl, a thrush, a species of Zosterops, and a small swift. The large fruit pigeon was very common, and its deep booming note was the most striking sound in the forest in the daytime. The small ground pigeon, with its bright metallic green back, gray head, and chestnut breast, was the most brilliantly colored of the island birds, but when running among the fallen leaves its colors harmonized so well with its surroundings that it was very difficult to see. The owl was chiefly remarkable for its peculiar note, which resembled the short bark of a small dog, usually repeated five or six times, but sometimes continued much longer. The seabirds were the most conspicuous of the inhabitants, the island being the breeding place of thousands of frigate-birds, gannets, boobies, etc. The frigate-birds and gannets built in the high trees near the coast; of the former there were two species, one considerably larger than the other. These birds were the most im-

FELLAHS CARRYING FILLING MATERIAL AND WORKING ON THE INCLINED PLANE OF THE LEANING COLUMN.



KARNAK—THE LEANING COLUMN OF HYPOSTYLE HALL, BEFORE 1895.



KARNAK—CENTRAL AISLE OF HYPOSTYLE HALL, RESTORED.

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portant source of food supply of the island. They were usually caught thus: A man, armed with a pole 10 feet or 12 feet long and a red cloth, climbed a high tree near the coast, and, standing on the topmost branch, waved the red rag. The birds were attracted by this, swooped round to investigate, and were knocked down with the pole; in that way enough to supply food for the few inhabitants could usually be obtained without much difficulty. The reptiles were few and small. There were five or six species of small lizards and a little blind snake, which lived in damp places under logs and rocks. Insect life was fairly abundant. There were several species of land crabs, the most common being a little red crab living in burrows all over the island. The robber crab was also very numerous. They were good climbers, and ascended trees in search of food. One remarkable circumstance was the occurrence of no less than four species of earthworms, two of which were peculiar to the island; the nearest allies seemed to be natives of Sumatra and the Aru Islands. It was difficult to account for the presence of those animals in an oceanic island, since both they and their ova were quickly killed by sea water. In conclusion, Mr. Andrews stated that for some years Mr. Andrew Ross, brother of Mr. George Ross, the owner of Keeling-Cocos Island, had been settled in Flying Fish Cove, with his family and a few men from Cocos. During his stay some substantial houses had been built, wells sunk, and fruit trees and cocoanut palms planted; a small experimental plantation of coffee was also made, and the results left no doubt that the island was well suited for coffee-growing. Recently a number of coolies had been imported from Java to make the necessary preparations for working the valuable deposits of phosphate of lime. When he (Mr. Andrews) left the island in May, 1898, the total population was about forty.—English Mechanic.

FILLING FOR SUPPORTING THE LEANING COLUMN.

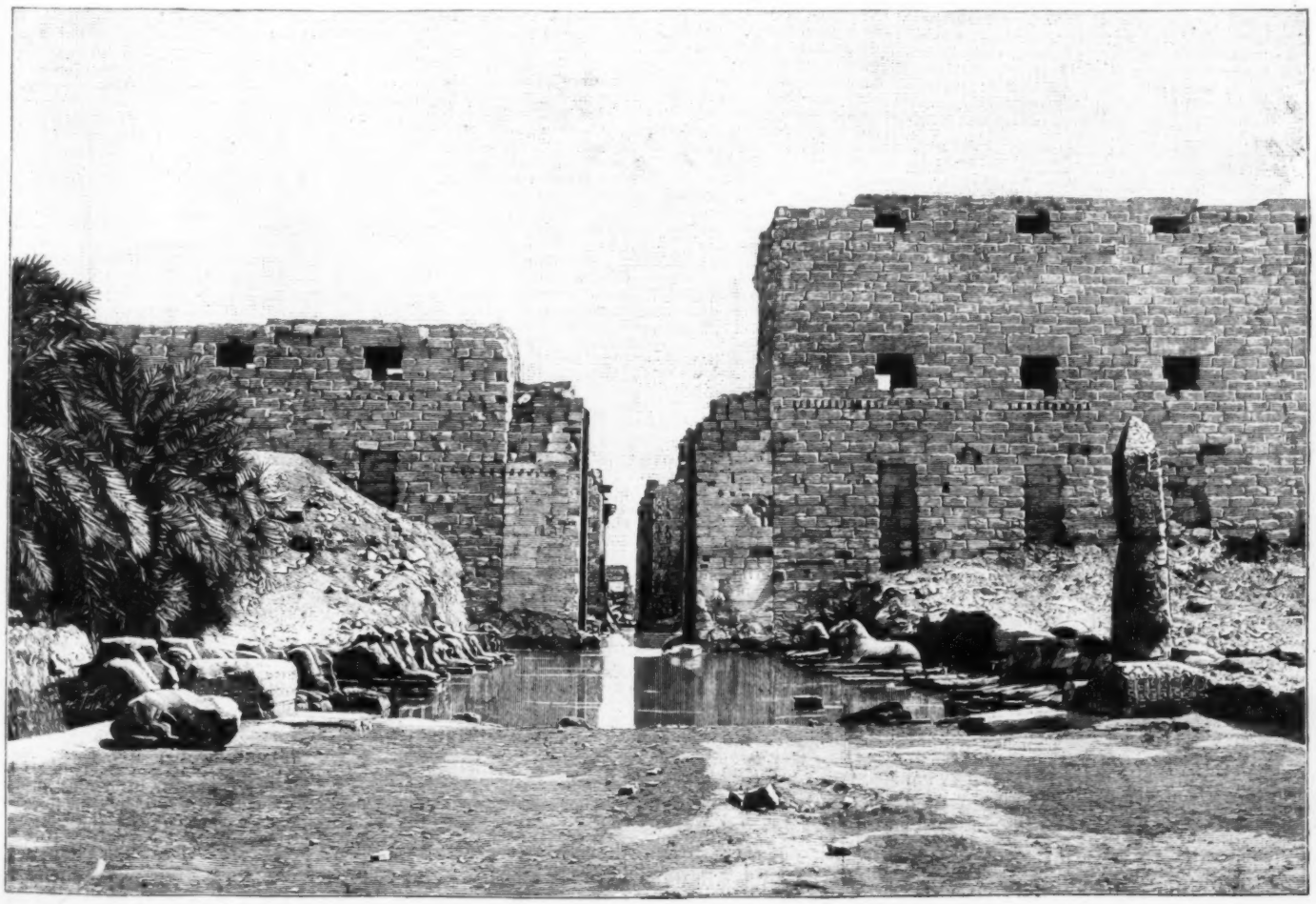
THE PLAN OF THE EARTH AND ITS CAUSES.*

IN a passage in the "Novum Organum" Bacon pointed out resemblances between the continents of the old and new worlds, which he thought showed that their shapes were not due to chance, but to the action of a common cause. Similar coincidences have been repeatedly noticed by geographers, who have accordingly been led to the belief that the distribution of land and water on the globe is based on a definite plan. Any such plan can only be recognized in broad outline, since geographical shapes depend on an intricate series of local accidents. Topographical form depends on such inconstant, incalculable factors that the stages of its growth are often untraceable. The missing links of geographical evolution are as numerous as those of organic evolution. Nevertheless, belief in the existence of a fundamental geographical plan is as old as geography. It was expressed in some of the earliest classical maps; it possessed the minds of mediæval cartographers, and led to their fantastic wheel maps; and it was popularized in the first half of the present century by the teaching of Humboldt and Elie de Beaumont. But with the growth of Lyellism and its doctrine of the interchange of land and sea under the influence of local variations in level, the idea fell into discredit.

But the discoveries of oceanography and geology have shown what allowances should be made for the obscuring action of minor oscillations, and thus have revealed fresh geographical homologies and explained apparent exceptions. The introduction of such local changes is, however, unnecessary, since the existence of a geographical plan of the earth is shown by three features: (1) The concentration of land in the northern and of water in the southern hemisphere; (2) the triangular form of the geographical units and the southward tapering of the land masses. From these two features it follows that there is a "northern land belt" from which three continents project southward, separated by three oceans, which expand until they form a "southern ocean belt." The third feature is the antipodal position of oceans and continents. The main problem of geomorphogeny is the explanation of these three facts.

The question is simplified by remembering that the earth consists of three parts: (1) The unknown inter-

* Abstract of lecture to the Royal Geographical Society on January 23, by Dr. J. W. Gregory.—Nature.



THE WESTERN PYLONES AFTER CLEARING THE ALLEY OF THE CRIOSPHINXES AND DURING THE INUNDATION OF THE NILE—THE ANCIENT QUAY IS SEEN IN THE FOREGROUND.

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nal centrosphere; (2) the rocky crust or lithosphere; (3) the oceanic layer or hydrosphere. Oceans and continents occupy respectively depressions and elevations of the lithosphere; and their distribution, therefore, directly depends on the distribution of the irregularities in its surface. If the existing irregularities have remained unchanged throughout geological time, then the problem is astronomical rather than geographical and geological.

The attempts to solve the problem on the basis of the permanence of the main geographical features may be grouped in four sets: (1) Prof. G. H. Darwin has attributed the main geographical lines to tidal wrinkles in the viscous crust; (2) Prinz has assigned them to torsion due to the acceleration of the equatorial and southern belts of the earth, and retardation of the northern land belt; (3) Sir J. Lubbock and Prof. Lapworth have independently explained continental form as due to the intercrossing of two sets of folds, one parallel to the equator and one at right angles to it; (4) Lord Kelvin refers back the main geographical divisions to an even earlier period than the previous theories, for he regards them as due to shoaling in the last molten layer of the globe, over areas determined by previous chemical segregations in the nebula. These theories are not necessarily inconsistent with the asymmetry between the northern and southern hemispheres; the primitive wrinkles, the double folds and the nebulous segregations are each in harmony with a considerable amount of geological evidence, but the theories are geographically inadequate, because they do not explain how the existing asymmetry has been developed. To do this, some more continuously acting cause is required, such as the secular contraction of the earth, on which Elie de Beaumont based his famous theory. His system, however, regarded the world as symmetrical, and was too rigidly geometrical to apply satisfactorily to a heterogeneous globe. In his "pentagonal réseau" antipodal areas were similar, for he regarded the world as a spheroid based on a pentagonal dodecahedron, which is a holohedral form; whereas, owing to the dissimilarity of antipodes on the earth, the lithosphere may be better regarded as hemihedral. The recognition of this fact led to the great advance on Elie de Beaumont's theory made by Lowthian Green, which has been advocated by De Lapparent and Michel-Lévy.

The tetrahedral theory does not regard the world as a regular tetrahedron; but suggests that, owing to the collapse of the earth's crust due to contraction, the lithosphere has undergone a tetrahedroid deformation. That collapsing shells tend to become tetrahedral, just as short tubes often collapse trigonally, is shown by experiments. "Nothing," says E. D. Preston, "is more in accordance with the action of physical laws than that the earth is contracting in approximately a tetrahedral form. . . . Experiments on iron tubes, on gas bubbles rising in water, and on rubber balloons, all tend to bear out the assumption that a homogeneous sphere tends to contract into a tetrahedron."

If such be the case, then the lithosphere would be depressed on four faces, which, being lower, would be naturally occupied by oceans; while the four projecting coigns would stand up as continents. In such a tetrahedrally deformed earth there would be a central ocean (the Arctic) on one face surrounded by a land belt, from which three meridional continents would run southward; they would each taper to a point, below which would be a southern ocean belt, from which three oceans would project northward. South of the ocean belt would be an Antarctic continent.

The arrangement of land and water on such an ideal, deformed globe would be identical with that on the earth; for there would be a northern concentration of land and a southern excess of water; the geographical shapes—except in the case of the two polar units—would be triangular, and land and water would be antipodal.

The agreement between the facts of geography and the requirements of the tetrahedral theory goes further. The main watersheds and mountain systems—which are by no means coincident—have both a tetrahedral plan forming a girdle in the northern hemisphere and three approximately equidistant meridional lines in the southern hemisphere.

The first obvious objection to the hypothesis of tetrahedroid deformation of the lithosphere is that physicists having proved the rigidity of the earth, any such deformation is impossible. But the arguments in favor of the earth's rigidity apply to the globe as a whole, and do not debar limited deformation of the crust. Such elasticity is now regarded as demonstrated by the movements of the pole, under such trivial influences as the unequal melting of the polar ice or unbalanced falls of snow. The second objection is that the earth is known to be an oblate spheroid, and therefore is not tetrahedrally deformed. But, owing to the equatorial flattening of the world, it is not a spheroid of revolution; owing to the differences of shape between the northern and southern hemispheres, it is not even an ellipsoid. Herschel pithily stated the facts in his remark that "the earth is earth-shaped;" and Listing's term "geoid" is now generally adopted for the figure of the earth. The geoid is, however, by no means a regular figure; the differences between the astronomical and trigonometrical determinations of positions show that the form is subject to numerous deviations, which cannot at present be attributed to any definite system; for accurate observations have not been made over a sufficiently large portion of the earth. But there are suggestions that, like the physical features of the earth, the major geodetic variations may be on a tetrahedral plan; for there is evidence of great deficiency of gravity in two areas (East Russia and Central United States of America), which may represent two of the three minima which should occur in the northern land belt. The ordinary explanation of these deficiencies in gravity—viz., that they are due to vast subterranean blocks of light material—is improbable; because in the Russian case the existence of such blocks is disproved by observations on deviations of the plumb-line (Helmert); and in the American case, Mendenhall has shown that no reasonable, or even possible, assumption will explain the facts. The agreement of gravity observations with Bessel's ellipsoid in Central Europe, and their approximation to Clarke's ellipsoid in Eastern Russia (as shown by Helmert), may indicate that both ellipsoids accurately represent the curvatures of the two areas on which they were mainly based, and that they merge into one another along the line of the East African meridional edge.

Geological evidence gives important support to the tetrahedral hypothesis, for the northern land belt appears founded on three great "schild" (Suess) or "coigns" of Archean blocks; these Scandinavian, Canadian, and Manchurian coigns are 120° apart. The significance of the angular distance between them was first pointed out by De Lapparent in the case of the first two. South of the coigns lines of elevation on the meridional edges would be expected; and, though the geological structure of the country along the three lines differs fundamentally, the three lines of recent or still continuing earth-movements of the Andes, Erythrean rift-valley, and East Australian coast occur in the right positions. That tetrahedral geological symmetry is not only an incident of the present, is shown by the distribution of land and water, and by the arrangement of the mountain system at the end of the Palæozoic; for both were on a tetrahedral symmetry. But in that period the present arrangement was reversed, the land belt being southern and the ocean belt northern in position; the position of the meridional land lines was the same as at present.

Such a change in the areas of tetrahedral flattening would be impossible in a stationary world; but in a revolving globe the collapse, due to contraction, is steadily resisted and confined within narrow limits by the effects of the rotation, which tends to restore the world to the more stable spheroidal form. The great mountain-building periods of the earth's history may be due to instability resulting from periods of slow deformation; and the periods of great marine transgressions (e. g., the repeated Mesozoic transgressions after the mountain elevations at the close of the Palæozoic) are easily explained as due to the restoration of more regular spheroidal form.

Hence the distribution of land and water on the globe may be regarded as the resultant of two opposing forces—collapse due to secular contraction causing deformations and the tendency due to the earth's rotation toward the recovery of the spheroidal form. The plan of the earth may be attributed to the continuous foundering of the lithosphere in consequence of the unceasing shrinkage of the centrosphere.

THE CUNNING OF CRIMINAL ANIMALS.*

A WELL written and well illustrated book with a colorless title often fails to attract readers, especially if, as in the present case, it is published in America, and deals with matters more familiar to that public than to ours. Mr. E. Seton Thompson, naturalist to the government of Manitoba, under the title of "Wild Animals I Have Known," has written a series of chapters on the cunning of animals. They bear evidence of very close observation and familiarity with the ways of some of these North American beasts; and though he has woven together the adventures of more than one creature in the same "personality," he gives his word that in the most remarkable stories there is "almost no deviation from fact." It is doubtful if the book gains in interest from the form in which the stories are presented; but apparently the example of the "Jungle Book" has been too strong, and he endeavors to give the facts in somewhat similar form. But either in the preface or in the text he is at pains to distinguish the salient facts from the setting, and it is to passages so guaranteed that we refer in this article.

Though cunning is a device of the weak, the weakness it indicates, even among animals, is entirely relative. We find three spheres of animal cunning, of very different quality. There is the cunning of the wolves and pumas, which use their wits to rob man of his flocks and cattle; the cunning of the domesticated creatures, which finds its development in criminal animals, and its worst example among the dogs which lead double lives, guarding their own flocks by day and killing others by night; and the cunning of self-preservation of the creatures on which others prey. The example given of the latter is the cottontail rabbit, a solitary species, not social like our rabbits, and a much cleverer creature. This is evidently the Brer Rabbit of "Uncle Remus," and the chapter on his thoughtful ways explains why he is selected as the Achitophel who gets the better of all the other creatures. The author claims for certain animals a share of the deference paid to depraved greatness—to wit, the bobtailed wolf which terrorized the whole city of Paris for ten years at the beginning of the fourteenth century; the Soehnee panther, which in less than two years killed nearly 300 human beings; and two creatures of North American fame, a lame grizzly bear, which in two years ruined all the hog raisers and drove half the farmers out of business in the Sacramento Valley, and a certain wolf of New Mexico, which (with its band) was reported to have killed a cow every day for five years. He visited the ranche which this creature infested, and witnessed the astonishing cunning it exhibited. The ranche was well watered and wooded in North New Mexico, giving good cover to the wolves, which, from the abundance of food afforded by the cattle, refused to look at any animal which they had not killed themselves, and when a "kill" was poisoned would not touch it. Their prey was mainly young cows and calves, and though in one night two of the pack killed 250 sheep, they did not eat any of the mutton. The band were led by a very large gray wolf, whose track was well known, being 5½ inches across, while other wolves' footmarks were only 4½ inches. They always ran from human beings, but were frequently seen. The big wolf was so well known that an increasing price was set on his scalp, till it reached $1,000, and the story of the campaign opens with the attempt of a professional hunter with a pack of dogs to run the wolves and "hold them up" till they could be shot. The wolves separated, so did the dogs, several were killed, and the hunter went back to Texas. Poison and traps were then tried, but the wolves avoided both, and the big wolf and his mate brought up a litter of cubs in some rocky precipices within a thousand yards of one of the farms, killing cattle every day. The author does not mention that the dog-wolf regularly feeds the cubs as soon as they are weaned, and is a good father of a family—a fact which makes this incident more than probable. It was at this period that Mr. Thompson made the acquaintance of the big wolf, and tried to kill him by scientific methods. He melted cheese in the fat of a heifer, in a china dish, cut it into lumps with a bone knife to avoid the taint of metal, and put into these strychnine and cyanide in odorproof capsules. He wore gloves steeped in cow's blood, and even avoided breathing on the baits. He found that one of these had been picked up, followed the track to the next, which was also gone, as was the third. At the fourth he found that the wolf had laid all four together and scattered dirt over them. The wolves then took to stampeding and killing sheep. Half a dozen goats were usually kept with each flock as leaders. Goats are not easily stampeded at night, and the sheep, when wolves were about, would crowd round the goats, and keep quiet while the shepherds drove off the wolves. The object of the latter is to stampede the sheep and pick them up, day by day, afterward. One night they ran over the backs of the huddled sheep, and killed all the goats in a few minutes. This may have been accidental, but it broke up the flock, and effected the desired object. Traps were set to the number of 130, in different parts of the ranche. The trail of the big wolf and of the pack were traced up to one set of traps, and the doings of the leader were plainly marked in the dust. He had stopped the rest, warned by scent, and scratched around the trap till he found the buried chain and picket. These had been left bare; and the same was done to a dozen other traps. On another part of the ranche he entered an H-shaped series of traps, and then detected the danger. The trail showed that he had slowly backed out on his own track, putting each paw down backward until out of the dangerous ground. He had then sprung some of the traps by scratching clods and stones backward at them, with his hind feet. He was at last caught by dragging over the traps the body of a female wolf, the scent of which he followed.

This wolf history represents the acme of animal cunning. The warfare against civilized man, raids made, as we may say, under the enemies' guns, could have been maintained for so long by no other animal, and represents the highest development even of wolf brains, which improve the further south they go, and consequently by contact and conflict with civilized man. The wolves of the "barren lands" of the far North are mere simpletons. Last summer they followed a hunter who had captured twelve musk ox calves for many days' journey, without devising means to kill one, though they followed the trail and sat within sight of his fire every night. The Currumpaw pack would have killed the musk oxen in a night. The cunning of the criminal dog is that of some forms of homicidal mania. He kills sheep usually to gratify his lust for slaughter; but Mr. Thompson states that he has heard of a dog who added to its nightly crimes that of murdering the smaller dogs of the neighborhood. He killed a number and hid their bodies in a sand pit. The details given of the life of a sheep-killing dog are, we think, taken from the records of one kept in Derbyshire. Poultry were killed by the dog, as well as sheep. In the Isle of Wight last winter some unknown dog made two such raids, in one of which it killed forty fowls in a single week. It was never discovered. The Derbyshire dog was noted for its care of its sheep, which belonged to a small lowland farmer, who, like others, ran his flock on the moors. The dog was, however, savage and ill-conditioned to strangers. It slept in the house and was never suspected, though sheep worrying took place on most of the farms near. At last it was tracked in the snow from a fold where twenty sheep had been killed, to the farm where it lived, the dog having apparently forgotten that the track would show, though it took partial means to conceal it by running along the top of a stone wall. The case was not proved till the daughter of the house slept in the kitchen where the dog lay, and saw it leap on the table, push through the window, and return with blood on its coat some hours later. It is not only by night these crimes are perpetrated by dogs. Some years ago, sheep were killed near a watering place in Devon by a mastiff owned by a lady. The proprietor of the sheep saw the dog go into a pool and bathe, close to a flock of sheep. The dog then ran off and joined its mistress on the road near. A newly killed sheep lay inside the fold, and though there was no clear evidence to establish the dog's guilt, it was sent elsewhere, and the sheep murders ceased.

* "Wild Animals I have Known." By E. Seton Thompson. New York: Charles Scribner's Sons. Reviewed in The London Spectator.

BATTLE BETWEEN ANTS.

A MISSIONARY who is in charge of the Catholic school at Mpala, on Lake Tanganyika, tells of an extraordinary battle between ants in his schoolroom, which the pupils and their teacher were compelled to abandon in haste when the invading foe appeared on the scene. The deserted room became the theater of a hotly contested battle between the ants that had their homes in the cracks of the stone walls and another species which advanced to the fight from the fields. The thousands of ants living in the walls are known to the natives as Masumbolo. They are very large and black, and as it is almost impossible to get rid of them, and they have the excellent quality of letting human beings alone, little attention is paid to them. The invading ants were not more than a third as large as the other species. They are called Siafou and are nomads and thieves by nature. When they discovered the home of the peaceful black insects, they felt certain that a rich booty of larvæ awaited them and lost no time in advancing to the attack.

The squadrons moved forward in close files. They clambered up the doorsteps and into the room, moving very rapidly, and began the fiercest sort of an attack upon the enemy, whom they surprised at home engaged in their peaceful occupations. Though the Masumbolo are so much larger than their fierce little enemies, they could not stand against these formidable aggressors, who are most effectively armed with the sharpest and hottest of pincers. So the attacked insects made scarcely any resistance, but gathered up as much of their larvæ as they could carry and fled at the top of their speed. They fairly carpeted the floor as they moved toward the doors, while their conquerors lost no time in further attack upon the unresisting fugitives, but began to pillage the city that had been so suddenly abandoned.

A few minutes later, however, the Siafou paid very dearly for the raid they had made. Dozens of the school children applied wisps of burning straw to the cracks which the conquering ants had entered and burned them at the very place of their victory.—N. Y. Sun.

ENGINEERING SOCIETY'S LIBRARY, 1365 UNIVERSITY OF MICHIGAN

ENGINEERING NOTES.

The equipment of the New York fire department includes a gun and projectile, to which is attached 500 feet of steel cable ¼ inch in diameter, knotted every 12 inches. The projectile is of steel and is discharged by gunpowder from the gun. The gun is aimed at a window where people are in danger, and when the thin line is secured it is used to pull up a heavier cable. It is stated that the apparatus has been used with good results.

One of the most urgent needs in steam engineering at the present time is a good automatic feed apparatus for water-tube boilers, says The Trade Journals Review. That which constitutes the principal merit of the water-tube boiler—the faculty of raising steam quickly—is what also renders it troublesome and risky. It contains so little water, and that is so quickly evaporated, it becomes necessary with this kind of boiler to have a constant feed flowing in at one end while at the other end it is flowing out in the form of steam. No intermission of this function can be permitted while the boiler is at work, for two or three minutes' cessation of water supply is often sufficient to burn the tubes and cause a serious disaster. It is this extreme sensitiveness of the boiler to fluctuations of water level that forms, perhaps, the principal obstacle to its more general use, for the utmost watchfulness is necessary on the part of the attendants to check or regulate the amount of feed in accordance with the engine's consumption. Many devices for automatic feeding have been tried and are now at work, but none of these can be said to be absolutely reliable under all circumstances. An automatic feed apparatus ought to be of the simplest construction, with no delicate parts that can be easily put out of order, and it must maintain the water at a certain level as fast as it evaporates. The task is a much more difficult one than might be supposed, but it is not insurmountable; and the man who can produce and patent a good apparatus of this character will have as much profitable work assured to him as he can desire.

There is at present being forged under the mammoth 12,000 ton hydraulic press at Parkhead Forge, Glasgow, seven sets of crank shafts of nickel steel, which are larger than any shafts of the kind hitherto undertaken by any forge. These are intended for the two large twin screw Atlantic liners "La Touraine" and "La Savoie," each of 11,000 tons and 22,000 indicated horse power, now under construction in the yard of the Compagnie Générale Transatlantique at Penhort, France. The ease with which the Titanic press manipulates the immense masses of nickel steel from which the finished articles are being fashioned affords striking evidence of the marvelous capability of this wonderful tool, says The Engineer. During the past year a large number of very notable productions in the way of nickel steel shafts have been produced by the Parkhead Forge, thus affording evidence of the increasing adoption of nickel steel for such important uses. Among the hollow nickel steel shafts were: Crank and straight shafting for the Japanese battleship "Asaki," shortly to be launched at Clydebank; crank and straight shafting for the Japanese battleship, and also for the Japanese cruiser, both building at Elswick, and crank and straight shafting for the royal yacht building at Pembroke dockyard. A fact of considerable note is that among the above shafts were two propeller shafts 16¼ inches diameter, and each of the great length of 74 feet 11¾ inches, with a hole bored through their length from 6 inches diameter to 11¼ inches diameter. At present the crank and straight shafting for the two first-class cruisers "Sutlej" and "Bacchante," building at Clydebank, are in course of manufacture; as also the connecting rods and other forgings for these vessels, and for H. M. S. "Cressy" and "Aboukir," the first-class cruisers building at Fairfield. An item of some note also in the work of the year was the axle for the gigantic wheel being erected at Paris, which is 26 inches to 29 inches diameter and 40 feet 8 inches in length, having a hole 15 inches diameter bored throughout. With disks fitted complete, this axle weighed over 31 tons.

In a paper on bilge keels, read before the American Society of Naval Architects and Engineers at New York by Assistant Naval Constructor Lawrence Spear, United States navy, some interesting figures were given relating to the steadying effect of bilge keels on the battleship "Oregon." Experience with the "Oregon" class at sea showed that some steadying influence was necessary; though the maximum inclination of the "Oregon" herself never exceeded about 22 degrees under a long low swell. Bilge keels were tried in January, 1898. They had a maximum depth of 34 inches near the ends, tapering to 14 inches amidships. The comparison in rolling effect, with and without keels, is shown in the following table:

	Keels.	
	Without.	With.
Date of trial	Dec. 30, 1897	Feb. 17, 1898
Draught forward	22 ft. 9½ in.	22 ft. 9 in.
" aft	23 ft. 8½ in.	23 ft. 8 in.
" mean	23 ft. 3 in.	23 ft. 2½ in.
Displacement	9810 tons	9790 tons
Metacentric height	3 ft.	3 ft.
Mean period single swing	7·6 secs.	7·83 secs.
Weight of coal	115 tons	50 tons
Weight of ammunition	26·7 tons	26·7 tons
Bilge keels, number	—	2
Length		297 ft. 6 in.
Greatest depth		34 in
Least depth		14 in.
Total area		830 sq. ft.
Effective radius		34·4 ft.

Except as above stated, conditions were alike in both cases. At slack water, and practically no current, with ship moored and without keels, 350 men running across the deck caused an inclination of about 7 degrees from the vertical; with 200 men acting in conjunction with the 8 inch turrets, an inclination of nearly 6 degrees was reached. Without bilge keels the rolling was practically isochronous within the range of experiments. With bilge keels the period for single swing decreased slightly with the amplitude of roll. As measured by the radius of gyration, the period without keels was 7·6, and that with keels 7·83—a difference of a little over 3 per cent.

ELECTRICAL NOTES.

An attempt is being made by an English company to secure a concession to build an electric wire rope railway from Aosta, in Italy, over the Great St. Bernard to Martigny, in the Rhone Valley. The cost is estimated at $2,895,000.

Arrangements are being made under the direction of Signor Marconi at the South Foreland lighthouse and on board the South Goodwin lightship for a series of experiments in wireless telegraphy. If the experiments are considered satisfactory, it is stated that the wireless system will be adopted forthwith as a means of communication between the South Foreland lighthouse and the South Sands Head lightship. The points of communication are about three miles apart.

The elevated railroads of New York city did not do as much business for the year ended June 30, 1898, as they did in the preceding year, but the street surface railroad business increased, says The Electrical Review. The State Railroad Commissioner reports that the total number of passengers carried by the elevated railroads was 227,776,552, a decrease of 1,019,129 as compared with 1897. The number carried by the elevated roads in the boroughs of Manhattan and the Bronx was 183,360,846, an increase of 395,995 as compared with 1897. The total number carried by the elevated railroads in the Borough of Brooklyn for 1898 was 44,365,706, a decrease of 1,465,124 compared with 1897. The street surface railroads of New York city carried as passengers the past year 456,963,753, including "transfers," an increase over 1897 of 57,538,010. The number carried in the Borough of Brooklyn (including some carried in the Borough of Queens) was 217,410,612, including "transfers," an increase over 1897 of 17,224,793.

The "inclosed" type of alternate current arc-lamp is much steadier in burning than its predecessors. It is therefore particularly well suited to photographic investigations as to the nature of arcs in general, using rapidly moving photographic plates. Mr. N. H. Brown, in The Physical Review, vol. vii., pp. 210-216, 1898, describes his experiments made with an "inclosed" arc. The pictures obtained are not simply broad, discontinuous bands of light. They exhibit, as a rule, a symmetrical arrangement of bright patches, in more or less regular alternation, the second patch being "reversed" to the first—like its image seen in a plane mirror. The front end of each patch makes an appreciable angle with the diameter of the plate, representing that the arc starts from one side and then from the other, successively. The shape of the back ends of the bright patches indicates that the light dies out first near the carbons, and later near the middle of the arc-space. The shape of the back and front ends of the bright patches does not seem to depend upon whether the current curve is or is not a true sine function.

In a borehole, about 300 m. (984 feet) deep, put down near Ostroppa, in the Gleiwitz district of Silesia, by the Ober-Schleische Tiefbohr-Gesellschaft Zollner & Company, the end of a boring rod was broken off, so that it became impossible to continue boring, owing to the pieces of steel in the hole, because all the diamond crowns were ground off. After three weeks had been spent in various but unsuccessful attempts to remove the pieces of steel, application was made to a representative of the Electricitäts Aktien Gesellschaft to extract the broken pieces in the following manner: A bar magnet was constructed ½ m. (4 feet 10 inches) long and 70 mm. (2¾ inches) diameter, which was surrounded by a single winding of wire insulated with India rubber, and was magnetized by the current of a small dynamo driven off the portable engine provided for the work of boring. The current was easily regulated by a simple water resistance, and kept to the constant quality of about 30 amperes. The magnet was let down unmagnetized; and, after it had come in contact with the bottom of the hole, the current was switched on to the winding through the rope used for letting down the magnet. On the first day that the arrangement was brought into operation, the pieces of steel in question were drawn up, so that boring could be continued. The pieces stuck so fast to the end of the magnet, capable of lifting 50 kg. (1 cwt.), that they could only be released by the application of force. Inasmuch as the work of boring is often interrupted by pieces of steel being broken off and becoming tightly jammed in the hole, this method, which constitutes a valuable addition to the accessories of boring, will probably be often employed.

At a recent meeting of the Vienna Gewerbeverein, Prof. Zickler, an Austrian savant, reported on a new kind of wireless telegraphy which he has invented. While utilizing a light electric phenomenon (first observed by Hertz) for the transmission of signs, he employs the invisible ultra-violet rays proceeding from a source of light, which rays have the property of setting free electric sparks at the receiving station. At the dispatching station the effective rays are produced by the powerful arc light of a reflector which sends them only in the direction of the receiving station, so that the possibility of the signs being intercepted in any other direction of space is excluded. Another property of these rays, viz., their being absorbed by glass, is a means of preventing diminution of the cone of visible rays on its leaving the reflector. This is effected by closing the mouth of the reflector with glass furnished with movable glass plates. Consequently, the effective invisible rays do not leave the reflector till its glass front is opened, and they produce in the receiver at the second station or terminus, the invention of Prof. Zickler, longer or shorter electric rays corresponding to the dots and dashes of the Morse alphabet, their length depending on the length of time during which the mouth of the reflector was open. It is easy to transfer these signs reproduced by the rays of an electric bell, a Morse electromagnet instrument or a telephone. Prof. Zickler showed his invention at the meeting, and with the help of an electric arc lamp he transferred signs to a writing apparatus and to a telephone at the other end of the room. He has extended his experiments to distances up to kilometers, and he hopes soon by means he possesses for increasing the effectiveness to be able to use this kind of telegraphy for distances which will enable it to be employed for divers practical purposes. —Engineering and Mining Journal.

SELECTED FORMULÆ.

The Persulphate of Ammonium Reducer.—Herr C. Baumann, in the Allgemeine Photographen-Zeitung, gives his experience with the persulphate of ammonium reducer. He fully confirms the observation that this salt attacks the dense parts rather than the more transparent portions of the negative, and he emphasizes its value, not only for reducing negatives, but also for reducing dark or overdone bromide prints. For this latter purpose a 1 per cent. solution is sufficient, and ordinarily no change in color takes place. For reducing negatives a 2 per cent. solution is most generally useful, but the strength may be increased even to 10 per cent. when a negative is over-dense. Herr Baumann has not noticed that continuing action in the wash water which is an inconvenience when other reducers are employed. As the solution of ammonium persulphate attacks the fingers, ebonite or celluloid hooks should be used to remove the plates.

Cloudy Ammonia.—Under the above caption the following formulas have been published:

1.	Ammonia water	1 gallon.
	Soft water	8 "
	Yellow soap	4 pounds.
	Saltpeter	8 ounces.

Cut the yellow soap in shavings and dissolve in soft water by heating; add the saltpeter and stir well until dissolved; strain, let settle, skim off all soap suds, etc., add the ammonia, and bottle at once.

2.	Methylated spirit	1 gallon.
	Soft water	1 "
	Stronger ammonia water	1 "
3.	Ammonia water	5 pints.
	Distilled water	5 "
	Soap	100 grains.
	Olive oil	5 drachms.

Cut the soap in shavings, boil with the oil and water, cool, add the ammonia water, and bottle. For use in laundries, baths, and general household purposes, add 1 tablespoonful to 1 gallon of water.

4.	Rectified spirit	4 fluid ounces.
	Water	4 gallons.
	Oil rosemary	½ ounce.
	Oil citronella	3 drachms.

Dissolve the oils in the spirit and add the water. Add 2 ounces fuller's earth, shake well and strain, then—

Ammonia water	2 gallons.
White curd or soft soap	2 ounces.

—Pharmaceutical Era.

Fireproofing of Tissues.—At the Berlin exhibition of means and contrivances for the prevention of accidents in industries and otherwise, prizes were awarded for the following processes of fireproofing, respectively, diminishing the combustibility of tissues, curtain materials, and theatrical scenery, viz.:

1. For light tissues: 8 kil. pure ammonium sulphate, 2½ kil. pure ammonium carbonate, 2 kil. pure borax, 3 kil. boric acid, 2 kil. starch, or 400 grammes dextrin, or 400 grammes gelatine, and 100 kil. water are mixed together, heated to 30° C., and the material impregnated with the mixture, centrifugated and dried, and then ironed as usual. One liter of the mixture, costing about 3 or 4 cents, is enough to impregnate 15 yards of material.

2. For curtain materials, theatrical decorations, wood, furniture: 15 kil. ammonium chloride are mixed with so much floated chalk as to give the mass consistency; it is then heated to 50°-60° C., and the material given one or two coats of it by means of a brush. A kilogramme of it, costing about 4 to 5 cents, is sufficient to cover 5 square yards.

3. For wood, cordage, straw matting, packing, cloth: 15 kil. ammonium chloride, 6 kil. boric acid, 3 kil. borax, are dissolved in 100 kil. water, the material laid down in the solution for 15-20 minutes at 100° C., squeezed and dried. One liter costs about 5 cents.

4. For paper, printed or not: 8 kil. ammonium sulphate, 3 kil. boric acid, 2 kil. borax, are dissolved in 100 kil. water, and the solution applied at 50° C.

Line Drawings on Photographs.—The Pharmaceutical Journal gives the following process for preparing line drawings on ordinary silver photographs, from which, of course, line "process" plates may then be made where half-tone illustrations are not desired. Any silver print may be used, but the old albumen or bromide papers give the best results. The print need not be deeply printed or toned; all that is necessary is to obtain a distinct image. The lines of any object in the print may now be inked over with a fine drawing pen, using a waterproof black ink. The drawing should be allowed to dry and then the silver image bleached out by the following bath:

Iodine	10 grammes.
Potassium iodide	40 "
Potassium cyanide	40 "
Distilled water to make	1,000 "

A short wash after the image has disappeared will leave the line drawing intact.

Leather Polish.—

1.	Sandarac	¼ ounce.
	Shellac	1 "
	Glycerin	1½ drachm.
	Castor oil	2 "
	Oil of mirbane	½ "
	Anilin blue	10 grains.
	Anilin black	1 drachm.
	Alcohol	8 ounces.

Wood alcohol, being cheaper than the grain spirit, might be used, or a mixture of the two would answer.

2.	Resin	2 drachms.
	Gum thus	2 "
	Turpentine	2 "
	Sandarac	4 "
	Shellac	1 ounce.
	Alcohol	7½ "
	Lampblack	1 drachm.

Dissolve all but the pigment in the alcohol, filter, and add the lampblack. Instead of lampblack, zinc white, ultramarine blue, or other similar coloring may be used. This is said to be elastic and unbreakable.—Druggists' Circular.

THE NEW STATION IN DRESDEN.

ALMOST at the same time that the jubilee of King Albert was being celebrated in the capital of Saxony, another event of great importance, the completion of the new main station, was marked with proper ceremony. In spite of her enormous foreign connection, the railroad station at Dresden was very inferior to those of Frankfort-on-the-Main, Hanover, Munich, and Cologne; but now she possesses one which is a masterpiece of the modern builders' art; and, on account of the combination of the terminus and the through station for international traffic, with elevated and sunken tracks, might serve as a model for future structures of this kind.

Our engraving shows the great station as seen from Bismarckplatz. The three parts stand out clearly. At the right and left, in great arched halls of glass and iron, are the elevated tracks for trains to and from Leipsic, Berlin, and Tetschen. Between the north and south halls are the sunken tracks for the Chemnitz-Reichenbach and Görlitz lines. On each side of the main building, with its fine dome, is a slender clock tower. Over the main entrance is a statue of Saxonia protecting Engineering and Machinery. If we enter the reception building, we are astonished at the splendor of the great space, decorated with paintings and ornaments in plaster. We feel that everything is well planned, and, in fact, the arrangement of the separate rooms, the ticket and baggage rooms, etc., could not be more practical. The comfort of the traveler is cared for so well that the most exacting requirements are satisfied. The waiting rooms are beautiful, especially those for first-class passengers. Here the eye is attracted by the finely executed views, copies of the drawings of Ludwig Storms, made at the Royal Porcelain Works, at Meissen. Unfortunately, our limited space will not permit a full description of the entire structure.—Für Alle Welt.

THE NEW MAIN STATION AT DRESDEN.

ANCIENT ENGINEERING.

By J. ELFRETH WATKINS, C.E., in Cassier's Magazine.

THE author has received the following communication from Dr. William H. Dall, of the United States geological survey:

During a visit to the island of Jersey (Channel Islands) in 1878, while wandering over the hills, I noticed, among many dolmens scattered about, one which seemed to have never been finished. The sides stood erect, and leading up to them were inclines over which such heavy weights as the roofing slabs of the dolmens could have been raised to the positions in which we find them. It was evident that cords and rollers, with a sufficient number of sturdy savages, would have been amply sufficient for the purpose in the case before me. The thorough manner in which the clay of the inclined plane had been consolidated was evident when it was considered that the denudation of it by the elements during unknown centuries had been insufficient to noticeably reduce its level or conceal its evident purpose.

The construction of the Egyptian pyramids, for centuries a matter of wonder, could have been performed by similar methods.

Let us see what labor this method would have involved in the construction of the pyramid of Gizeh, the largest of its kind, which is approximately one hundred and fifty yards high and two hundred and fifty yards square at the base! As is well known, in building this pyramid, which is located three miles south of Cairo, two kinds of stone were used, limestone and red granite. The limestone was quarried at El Massarah, forty-five or fifty miles from Gizeh, while the red granite was brought from Assouan, near the First Cataract, over five hundred miles. Both of these quarries were located on the River Nile. In the foreground of the illustration, not reproduced here, are to be seen rafts laden with stone blocks, brought from the quarries. Upon the sloping embankment blocks are being drawn on sledges, perhaps equipped with rollers, to the highest point to which the structure has been built, the inclined plane being gradually made longer and higher with earth brought from the pits on the right and left. The highest embankment necessary when the workmen reached the top course, assuming that a twenty per cent. grade was adopted, would have been seven hundred and fifty yards long, containing about seven and one-half million cubic yards, if the sides of the earth embankment would stand at an angle of thirty degrees, which is not at all improbable. Assuming that one laborer could have placed two and one-half yards (about twenty barrow loads) of earth on an average each day on this embankment, 10,000 men could have built it in twelve months of twenty-five working days each. It is stated that one hundred thousand men were employed for twenty years in the whole work; so that, according to this calculation, the construction of this embankment would have occupied only a small portion of the total time consumed.

The false work to support the walls of the interior chambers of the pyramids could also have been made of earth rather than of timber. It should be remembered that heavy lumber for scaffolding must have been brought over long distances, and that the framing and erection of any structure of sufficient strength to bear heavy weights would have required more skill and knowledge than the building of the pyramid itself by the method above described. In the great temple of Rameses II. is to be found a colossal statue of that king, which equals in dimensions and exceeds in weight any other Egyptian monolith, being sixty feet high and weighing eight hundred and eighty-seven tons five and one-half hundredweights. It was made from a single block of red granite brought from the quarries at Assouan, one hundred and thirty-five miles distant, by the River Nile. At Baalbec, Syria, are to be found the ruins of three temples, one of which has been given the name of Trilithon, "Three-stone temple," from the extraordinary proportions of three of the stone blocks found in it, each being over sixty-three feet in length, thirteen feet in height, and proportionately thick. The stones now rest in a wall over twenty feet above the present surface of the ground.

In the solution of the problem of putting similar huge blocks in place at the present day, the utilization of inclined planes of earth in the manner just described might well be considered by the modern engineer before adopting a more complex method. In fact, since the various details of this method of construction have suggested themselves, the writer has examined photographs of many ancient structures, and has yet to find one that could not have been constructed to a great extent according to the practices just described. Until the principles of the true arch were understood, it was less difficult to move and erect long blocks of stone by these primitive methods than to place smaller units over the openings of structures designed in accordance with the types of ancient architecture, in which the arch, with a keystone, was lacking. Especially was this true in an era when the value of time was not considered, and slaves were to be obtained by thousands, at small cost, to toil and sweat to gratify the ambition and perpetuate the fame of kings.

Proud as we may be of the advances made by discovery and invention in our age, we must not forget that the patient perseverance of the engineers of antiquity, who, by brawn and muscle, and unaided by mechanism, built wiser than they knew, have been rewarded by the preservation of an indelible record of their achievements in the material remains of their edifices that have withstood the ravages of centuries. Will fate so favor the engineer of the nineteenth century, versed in the laws of modern science, and skilled in the practice of the mechanic arts?

THE ZINC INDUSTRY.

THE following report has been issued by C. Kirchhoff, agent of the United States Geological Survey. During the year 1898 the production of spelter in the United States was as follows:

PRODUCTION OF SPELTER (SHORT TONS).

States.	1898.	1897.	1896.	1895.	1894.
Eastern	8,631	7,218	8,139	9,484	7,300
Southern		3,365	2,427	3,097	1,570
Illinois and Indiana	47,102	37,876	36,173	35,732	28,972
Kansas	40,132	35,396	29,759	25,775	25,588
Missouri	19,503	18,125	14,001	14,998	11,992
Totals	115,399	99,980	81,499	89,086	75,328

It will be observed that the greatest increase in output has taken place in Illinois-Indiana and in Kansas.

An important movement was initiated in 1898, and is still in progress, being the transfer of some old plants and the establishment of new works in the Kansas gas belt. Robert Lanyon's Sons Spelter Company first established a large plant at Iola, and followed it with new works at La Harpe. W. & J. Lanyon, at Iola, added to the 600 retorts at work in January a like number in February, and increased the plant to 1,800 retorts in November. The works No. 6, at Scammon, of the Cherokee-Lanyon Spelter Company, have been dismantled, and have been removed to Iola, Kan. They are not yet in operation. The Prime Western Spelter Company are a new works at Iola, Kan., which commenced to make spelter about February 1 with 600 retorts, having a capacity of from 450,000 to 500,000 pounds monthly. This capacity is to be doubled in a short time. Another new plant, just started, is that of George E. Nicholson, at Iola, Kan. There have been fired up 600 retorts, and 600 additional are to start about the middle of March. The Edgar Zinc Company are now building a 1,200-retort plant at Cherryvale, Kan., which, it is expected, will be in operation in June.

In Indiana the Fairmount Zinc Company began operations with 300 retorts, having a capacity of 300,000 to 400,000 pounds per month. It is the intention to double the plant in spring.

Among the older works, the following changes may be noted: The Collinsville Zinc Company, at Collinsville, Ill., have increased their capacity 50 per cent.: the North Chicago plant of the Empire Zinc Company started another furnace in October, increasing the capacity 50 per cent.; the Humphrey Spelter Company have made additions which carry the monthly capacity up to 500,000 pounds; the Girard Smelting Company, at Girard, Kan., have leased from the Cherokee-Lanyon Spelter Company the two plants of the Girard Zinc Company and the Kansas Zinc Mining and Smelting Company; the Cherokee Smelting Company have leased the No. 12 plant of the Cherokee-Lanyon Spe-

ter Company, at Cherokee, Kan.; the Columbia Zinc Company are now operating the Marion, Ind., plants.

The export statistics for the whole year 1898 are not yet available. For the first 11 months the exports of ore and spelter were:

	1896.		1897.		1898.	
Ore—gross tons	1,425	$20,906	7,252	$188,090	10,254	$291,870
Spelter—net tons	9,601	947,828	12,865	1,319,348	9,535	937,631

This indicates a considerable falling off in 1898.

APPARATUS FOR CONSUMING SMOKE.—I.

THE question of the consumption of smoke is far from being a new one, for the inconveniences of the latter have made themselves felt ever since the period at which the use of coal became widespread. They have been especially grave in industrial cities, and it was England that was the first to suffer severely therefrom. As long ago as the sixteenth century, the atmosphere of the city of London was greatly defiled by coal smoke, and King Charles II. busied himself with the subject of remedying the nuisance, and to this effect caused repressive arrangements to be prepared. The police authorities of various cities, such as Leeds and Manchester, promulgated regulations at different times, and, after the local authorities, the government took the question in hand, whence the commissions instituted in 1819, 1843, and 1847, and the act designated as the Palmerston, from the name of the minister who countersigned it in 1853. New regulations were made in 1858, 1866, 1885, and 1891.

Papin and James Watt, the illustrious engineers, occupied themselves with the important problem of smoke consumption, and the former devised a system of combustion with reversed flame—a mechanical apparatus that produced the strong current of air necessary. Yet, as ingenious as this arrangement was, the conversion of the coal into coke and the want of a suitable aspirator prevented the success of it.

James Watt's patent described the following arrangement: There was no grate, but the coal rested upon a surface of bricks. The air, drawn through the furnace door, which was provided with a conical aperture, passed first through the non-ignited coal. The combustible gas, mixed with air, had therefore to traverse either the stratum of ignited coal or pass through flues at a high temperature. In practice, there were difficulties encountered due to the compactness of the coke that formed.

Following Papin and Watt, we find among the inventors of smoke-consuming apparatus the well known names of William Thompson (1796), Roberton, of Glasgow (1801), and Messrs. Clement and Desormes (1802). Later on came the studies of Combes upon the grates and furnaces of Jackes and Tailfer. Later still appeared the Marsilly grates and the Dumery apparatus, which were held in some esteem for a long time.

By the terms of a decree of August 8, 1894, the sum of 17,000 francs was set aside for the award of three prizes of 10,000, 5,000, and 2,000 francs to the inventors of the best smoke-consuming devices presented for competition.

The number of competitors who presented themselves was 110, who, from the standpoint of nationality, were distributed as follows: French, 76; English, 19; Germans, 4; Americans, 3; Austro-Hungarians, 3; Italians, 2; Belgian, 1; and of unknown nationality, 1.

The technical commission having the examination of these projects in charge was composed of the following members: M. Huet, inspector-general of bridges and roads, president; M. Brull, former president of the Society of Civil Engineers; M. Hirsch, engineer in chief of bridges and roads; M. Humblot, inspector-general of bridges and roads; M. Lamouroux, member of the municipal council; M. Levy, engineer in chief of mines, etc.; and M. Meker, inspector of engines of the city of Paris.

After a first examination, the commission retained provisionally thirty projects that seemed to merit a deeper study and to be worthy of being submitted to practical experiments that should permit of ascertaining what systems best responded to the two conditions imposed by the commission, these being (1) that no troublesome smoke should be emitted with ordinary combustion, and (2) that the apparatus should satisfy the economic and industrial requirements of steam generators.

The works selected for the experiments were the municipal ones of Quai Javel that serve for raising water taken from the Seine. These works embrace a battery of three identical generators and two water-raising engines. Each boiler ordinarily suffices to supply one engine, and, when driven, is capable of supplying both engines.

The height of elevation of the water and the rotary velocity of the engines are sensibly constant, and these were excellent conditions for assuring uniformity in a comparison of the results. The presence of three generators in the same battery gave valuable facilities. The two extreme generators were devoted to the experiments, and the central one was not fired. While the experiments with one system were proceeding with one of the extreme boilers (No. 1, for example), the boiler at the other end of the battery (No. 3) was being used by another competitor, who thus had all the time necessary to establish his apparatus without in any way interfering with the operations going on at the other extremity of the battery.

The generators of the Javel works are of the semi-tubular type. They consist of a cylindrical body with flat ends, 4·5 feet in diameter and 11·5 in length, traversed by a bundle of fifty smoke tubes of 3 inches internal diameter surmounting two cylindrical water spaces connected by upright tubes.

The total heating surface is 730 square feet, the total volume 279 cubic feet, and the register 98 pounds to the square inch.

The fuel selected for the experiments was Anzin briquette of ordinary quality, which is passably smoky and of sensibly constant composition.

Measurement of the Smoke Intensity.—This delicate and essential part of the experiments was performed by direct observation. The indirect processes that were proposed did not, despite their apparent precision, seem to the commission proper for furnishing in a certain manner the most essential datum, that is to say, the degree of pollution of the atmosphere surrounding the top of the chimney. But the direct process, which consisted in a simple estimation, at sight, of the volume and density of the smoke emitted, needed to be precise and verifiable. To this effect, two stations for observation were selected. These were at about 1,000 feet from the chimney and at the level of the furnace top—one at the north and the other at the south—so that for all the winds prevailing the smoke produced had a direction nearly at right angles with the sight, and spread out for observation in its whole extent. These stations were the windows of rooms situated in the upper story of two houses—one on Rue Saint Charles and the other on Avenue de Versailles. Without entering into the details of the processes employed for assuring the accuracy of the observations, it will suffice to mention the graphic inscription by mechanical means upon cross section paper moved by clockwork. The graphic daily planimetered and a division by the time elapsed gave the mean intensity of the smoke during the time of the experiment. It is remarkable that the results furnished by the two observers operating isolatedly closely agreed. In addition to such control, the fuel burned was weighed, and the hour of each charging, as well as the number of shovelfuls of which the charge was composed, was noted.

The quantity of water vaporized also was measured, and the manometric pressure was taken every five

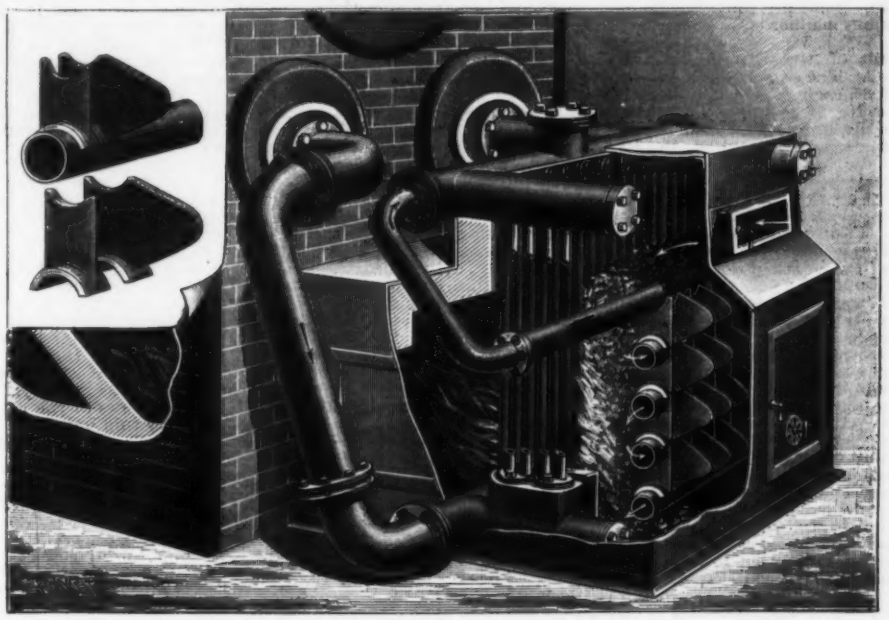

FIG. 1.—THE DONNELY APPARATUS

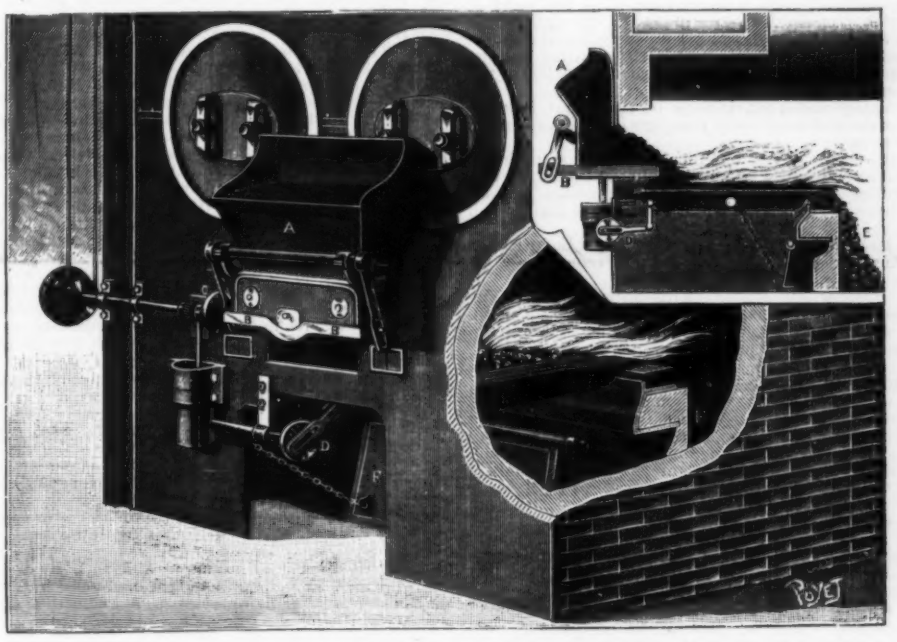

FIG. 2.—THE PROCTOR APPARATUS.

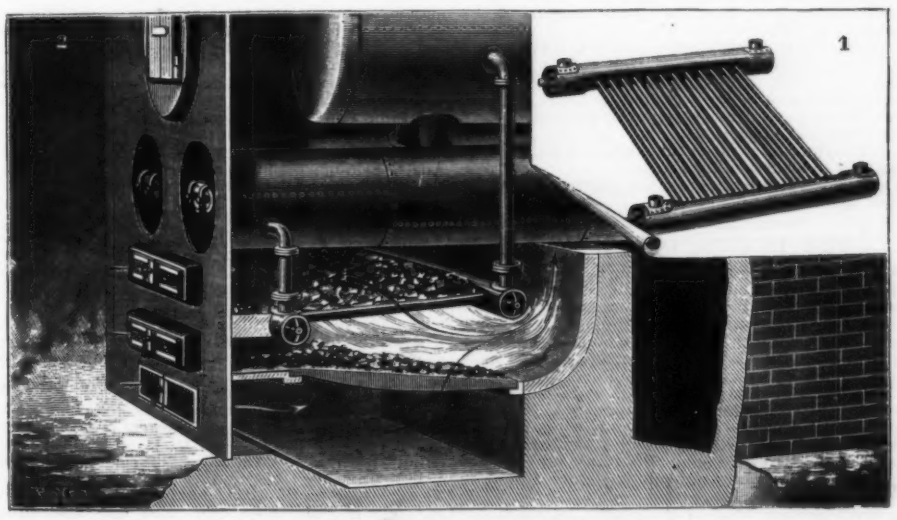

FIG. 3.—THE HAWLEY APPARATUS.

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minutes. Such pressure, besides, was furnished in a continuous manner by a Richards registering apparatus.

Results of the Experiments.—No first prize was awarded. The second was divided between apparatus 24 and 85, each of which obtained 5,000 francs. Apparatus No. 24 was that of Mr. Donnely, and No. 85 that of Mr. James Proctor. The Hawley smoke-consuming furnace, presented by Mr. C. Kiandi, and classed as No. 19, took the third prize (2,000 francs). Honorable mention was awarded to Messrs. Dulac, Hinstin and Orvis, whose systems bore the respective numbers of 26, 47, and 74.

We shall now pass rapidly in review such interesting apparatus as attracted the attention of manufacturers and municipalities.

The Donnely Apparatus.—As shown in Fig. 1, this apparatus consists of a grate in the form of a rectangular box in which the fuel is placed, and which is connected with the flues through a combustion chamber of fire bricks. The sides of the box are of openwork and composed of tubes through which water circulates. The air enters through the front side and traverses the incandescent coal, and the flames, after surmounting the rear wall, distribute themselves through the combustion chamber. The rear and side walls are formed of vertical tubes that connect at the top and bottom with horizontal collectors. The front face consists of widely spaced horizontal tubes, the intervals between which are filled in with small movable bars, with the exception of the upper interval, which remains open and forms a mouth for the charging. These tubes are mounted in series, that is to say, they form a sort of continuous spiral connecting through its extremities with the two collectors. The fuel, introduced through the mouth, gradually descends in measure as the combustion proceeds and becomes converted into coke. The ashes accumulate at the bottom and are removed from time to time through the interval existing between the sill of the grate and the horizontal tube of the bottom, and which is not provided with movable bars. The products of distillation disengaged at the top of the grate and the hot gases that have traversed the coke at the bottom afterward become mixed in the combustion chamber.

The access of the air is regulated, concurrently with the register, by latticed mouths formed in the iron plate doors in front of the furnace. The upper collector is connected by a short tube with the head of the water space to the right of the boiler and sends into it the steam disengaged in all the tubes that form the grate. The return is effected through an oblique conduit that connects the water space at the left of the boiler with the lower collector.

Practically speaking, it may be said that this apparatus showed itself to be completely and absolutely fumivorous.

Yet the report of the technical commission makes a few reservations. It asks how in ordinary service these tubes of water exposed to an immediate contact with the incandescent fuel and most active flames will behave.

The management of the apparatus must be intrusted to skillful and conscientious persons to render it free from accidents.

The Proctor Apparatus.—This apparatus is a mechanical feeder, with an arrangement for the automatic cleaning of the grate (Fig. 2). The coal, thrown into the hopper, *A*, is pushed forward by two slides, *B*, which have a horizontal alternating motion that is communicated to them by the eccentric, *C*. The grate, which slopes toward the rear, consists of bars that are successively fixed and movable. To the movable bars is given, through levers, *A*, a rising and horizontal motion under the action of an eccentric, *D*. At each oscillation, the coal lying upon the grate is moved slightly toward the rear, and finally falls, in the state of cinders and ashes, into the pit, *E*, where the combustion terminates.

In this system the smoke consumption was nearly complete in the experiments at Javel. The apparatus is simple and plain, and takes up but little space, but is quite costly as regards installation.

The Hawley Apparatus.—This apparatus consists of two superposed grates. The upper one of these, the bars of which are water tubes, receives the charge of fuel directly, and the flames traverse it in descending (Fig. 3). The lower grate receives the fuel that falls through the upper one and finishes the combustion of it.

The air enters both above the top grate and beneath the lower one. The flames mingle in the space between the two grates and afterward enter a combustion chamber and thence escape into the flues. In this apparatus, which is of American origin, and which is certainly interesting, the combustion proceeds with reversal of the flames. The bars are hollow, with a circulation of water therein. The smoke consumption is far from being complete, but the utilization of the fuel is very satisfactory.

The apparatus is delicate and must be intrusted only to skilled hands, if it is desired that safety shall be assured. In addition, the construction of it is costly. The application to a boiler provided in front with an ordinary furnace requires a complete transformation of the fore part of the hearth.

The three other apparatus that received awards will be described in a succeeding article.

For the above particulars and the engravings we are indebted to La Nature.

THE PHYSICS OF SMELL.

THE principal subject of Prof. W. E. Ayrton's vice-presidential address on physics at the British Association was the physics of smell, which was presented as a subject that had been but little studied. In testing the generally accepted idea that metals have smell, based on the fact that a smell is perceived with most of the commercial metals when handled, the author had observed that when these metals were cleaned or made outwardly pure the smell disappeared. Yet it is shown that these metals acquire smells, when they are handled or abraded by friction, which are characteristic and serve to distinguish them. This may be ascribed to chemical action, but not all chemical action in which metals may take part produces smell; for, when they are rubbed with soda or with sugar, no smell but that of soda or of sugar is perceived; nor is the metallic smell observed when dilute nitric acid is rubbed on certain metals, though the chemical action is very marked with some. But mere breathing on certain metals, even when they have been rendered practically odorless by cleaning, produces a very distinct smell, as also does touching them with the tongue. These smells have hitherto been (attributed to the metals themselves, but Prof. Ayrton looks for their source in the evolution of hydrogen which carries with it impurities, hydrocarbons, especially paraffin, and "it is probable that no metallic particles, even in the form of vapor, reach the nose or even leave the metal. While smells usually appear to be diffused with great velocity, experiments prove that when the space through which they have to pass is free from draughts their progress is very slow, and it would therefore appear that the passage of a smell is far more due to the actual motion of the air containing it than to the diffusion of the odoriferous substance through the air." The power of a smell to cling to a substance does not appear to depend on its intensity or on the ease with which it travels through a closed space. Experiments to determine whether smells could pass through glass by transpiration either revealed flaws in the glass or ended in the breaking of the very thin bulbs and gave no answer.—December Appleton's Popular Science Monthly, New York.

SOUND AND THE ATOMIC CONSTITUTION OF GASES.

To the Editor of the SCIENTIFIC AMERICAN:

In an article entitled "Companions of Argon," in the SCIENTIFIC AMERICAN SUPPLEMENT of December 3, 1898, occurs a reference to a method of finding the number of atoms in the molecule of a gas based upon a determination of the wave length of sound in this gas as compared with the wave length in air. To the non-technical reader the possibility of the relationship indicated seems remote, and a few words of explanation may not be amiss.

The formula for the velocity of sound in a gas is

$$V = wn = \sqrt{\frac{gp}{r}}$$

where r is the density and p the pressure of the gas, g the ratio of the specific heat at constant pressure to the specific heat at constant volume, and w and n respectively the wave length and frequency of a given tone. The proof of the formula may be found in any mathematical work on sound.

Now, it is known as an experimental fact that the specific heat of a gas at constant pressure is greater than the specific heat at constant volume. This is a result to be expected, since in the first case external work is done in addition to the increase of internal energy, common to both cases, due to the rise of temperature. The ratio of these two quantities for a monatomic gas has been found, both experimentally and by calculation, to be 1·66, while for air and the common diatomic gases it is found to be only about 1·4. The difference between the two is supposed to be due to work done inside the diatomic molecule.

Suppose now it is desired to ascertain the number of atoms in the molecule of a new gas after having found, experimentally, its density and the wave length of a particular tone. For any two gases, as, for instance, air and the gas in question, assuming the same pitch of sound and the same pressure, we may write the proportion $w^2 : w_1^2 :: g/r : g_1/r_1$ from which

$$g_1 = \frac{w_1^2 \, g r_1}{w^2 r}$$

The value of g from this will determine, as indicated above, whether the gas is monatomic or diatomic.

The solution of the particular case in the article referred to depends upon the following data: density of new gas 19·87, wave length in the gas 31·68, wave length in air 34·18, density of air 14·43, and ratio of specific heats for air 1·408. By substitution of these values in the above equation there results $g_1 = 1{\cdot}66$, which shows that the gas is monatomic. C. M. BROOMALL.

Media, Pa., January 14, 1899.

GERMANY'S ASSISTANCE IN FURTHERING TRADE.

THE great interest in Asiatic commerce which other nations as well as the United States are now feeling is illustrated in a recent subsidy agreement made by the German government by which it proposes to pay more than a million dollars a year for a fifteen-year term for the establishment of steamship lines to ply between its ports and those of Japan, China and Australasia and certain ports of Oceanica. That the German government and those of its citizens participating in its commerce should feel a special interest in the trade of the Orient is not surprising in view of the fact that its exports to that part of the world have quadrupled during the past decade.

A copy of the contract between the German government and the Lloyd steamship line for the establishment and maintenance of postal and commercial communication between Germany and Eastern Asia and Australasia has reached the Treasury Bureau of Statistics. It shows that the Lloyd Company agrees to maintain for a space of fifteen years steamship lines running from Bremerhaven or Hamburg, Germany, by way of a Belgian or Dutch port through Genoa, Naples, Port Said, Suez, Aden, Colombo, Singapore, and Hong-Kong to Shanghai, China, and back by the same route; a second main line through the same ports to Yokohama, Japan; also a main line through the same ports to Adelaide, Melbourne and Sydney, Australia; also branch lines from Hong-Kong to Shanghai and from Singapore to German New Guinea and other ports in Oceanica.

Four steamers are, under this contract, to be built for the Chinese and Japanese service, to be of not less than 6,000 tons and equal to those of foreign nations in every respect, their plans to be approved by the Admiralty, and to be running respectively by October 1, 1899, January 1, September 1, and November 1, 1900. The steamers to be constructed for the Australian line are to be not less than 5,300 tons, and also equal to those of foreign nations in every respect and subject to the approval of the Admiralty. All the ships are to be built in German yards and German material is to be used as far as possible, all Admiralty requirements to be carried out in them, putting them into condition in which they can readily be utilized for war purposes when necessary. The agreement provides that in cases of mobilizing the fleet the Chancellor can purchase the vessels on full payment of their value, or can hire them. The terms of the contract also provide that only German coal is to be taken on board at German, Belgian, or Dutch ports of call, except by the special assent of the Imperial Chancellor; that in cases of German and foreign goods being simultaneously offered for dispatch, the German goods are, if necessary, to have the preference, and that the Chancellor may prohibit the importation by German, Belgian, or Dutch ports of such agricultural products as may compete with those of German agriculture.

The agreement provides that the German government shall pay to the Lloyd Company 5,590,000 marks per year, payable monthly. (Value of mark 23·8 cents.) This contract extends from April, 1899, for a term of fifteen years; the regular plan of sailing on the Japanese line must begin at latest in April, 1899. It is also announced that a Bremen firm intends to establish, with steamers now being built for that purpose, a steamship line on the Yangtse Kiang in China, to ply between Shanghai and Hankow. By the aid of these lines, which will connect with the subsidized lines running from Hamburg to Shanghai, German dealers and German interests will be in direct communication not only with Shanghai, which has two-thirds of the import trade of China, but also with Hankow, one of the most important commercial cities of China, having a population of about 1,000,000. It is now being connected with Peking by railroad. Hankow is probably the most important of the distributing centers of interior China, being splendidly situated in the very heart of the country, surrounded by a network of rivers and lakes, and reached by the largest ocean steamers, and when to this is added the railway system now under construction, its importance as a distributing point for interior China is very great.

Germany's exports to the Asiatic countries have increased very rapidly during the past decade. Her exports to China in 1887 amounted to 14,309,000 marks in value, and in 1896 to 45,266,000. To Japan the 1887 exports were 6,398,000 marks, and those of 1896, 35,611,000. To British East Indies they were in 1887, 7,230,000, and in 1896, 49,179,000 marks. To Dutch East Indies and the Philippines they were in 1887, 5,849,000, and in 1896, 16,943,000. To Australia they were in 1887, 7,470,000; in 1896, 29,247,000 marks.

[Continued from SUPPLEMENT, No. 1207, page 19357.]

TUBERCULOSIS IN ANIMALS.*

By W. HUNTING.

VOLUNTARY EFFORT PLUS INSPECTION OF MEAT AND MILK.

THOSE who would rely upon voluntary effort for the control of tuberculosis in animals overlook the danger to human beings, and treat with too little gravity the constant infection of man which results from disease in cattle. This danger received recognition when, in 1896, a Royal Commission was appointed "to inquire what legislative procedures are advisable, and would be desirable, for controlling the danger to man through the use as food of the meat and milk of tuberculous animals." This commission issued a report in 1898 which recommended:

(1) That local authorities should have powers given them to erect public slaughter houses, and provide for the inspection of meat.
(2) That the Local Government Board be empowered to issue instructions prescribing the degrees of infection which cause a carcass to be seized in whole or in part.
(3) That notification by the owner of every disease of the udder of cows should be made compulsory.
(4) That milk should be analyzed and tested.
(5) That cowsheds should be kept in proper sanitary condition.
(6) That the Board of Agriculture should assist stock owners to detect disease in their animals by the offer of a gratuitous tuberculin test, under conditions that compel separation and isolation of all diseased animals.

These authoritative recommendations are a very great advance upon mere voluntary efforts. The regulations applying to butchers and cowkeepers are stringent, especially the one requiring notification of all udder diseases. Even the gratuitous tuberculin test is made subject to conditions of separation and isolation equal to any similar regulations now applied to other diseases under the Animals Diseases Act.

It will be noticed that the commission was limited by its instructions to the question of protecting human beings from the danger of tuberculosis in animals. It, therefore, made no suggestions for the control of the disease in cattle except such as would indirectly follow voluntary efforts on the part of stock owners, and the conditional use of tuberculin by the Board of Agriculture. The fact is the commission could do no more, and their report is to be looked upon as the irreducible minimum of necessary legislation for saving human life. I shall try to show that their instructions so limited their view of the subject as to render it insufficient for any useful legislation, and that what they desire to attain can be more easily and certainly arrived at by a different course—by a course that will not only protect man, but will also assist the agriculturist, and do justice to the cowkeeper and butcher. The report of the commission certainly did good by directing public attention to the subject, but its suggestion for compulsory interference without payment of compensation has alienated many of the interests concerned. By a majority of one the commission decided against payment of compensation to the butchers for seizure of tuberculous carcasses. Thus, by one man's vote, the meat trade has been made to take a position of opposition to proposed legislation, and the agriculturist has accepted the no-compensation verdict as an

* Journal of the Society of Arts, London.

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authoritative hint of what he may expect should he assent to any administrative action.

LEGISLATIVE CONTROL.

To know what authoritative opinion on tuberculosis in animals is, we must read with the report of the 1898 commission the recommendations of a Departmental Committee which took evidence in 1888 on the question of measures required to control the disease in animals. It reported: That in order to insure the gradual extirpation of tuberculosis, we are of opinion that it should be included in the Contagious Diseases (Animals) Act for the purposes of:

(1) Slaughter of diseased animals.
(2) Payment of compensation for slaughter.
(3) Seizure of diseased animals in fairs and markets, or during transit.

Reading these recommendations in conjunction with those of the recent Royal Commission, we obtain guidance as to the necessary measures for the protection of man and animals. The two objects are not separable. The control of tuberculosis in animals and in man is one subject, and unless the double object be kept in view, administrative measures will be partially applied, insufficient, and unsuccessful.

I am supported in this contention by the report of the Royal Commission, which clearly recognized the insufficiency of its recommendations, and says: "All precautions against the communication of tubercular disease to human beings (from the consumption of meat or milk of diseased animals) must be regarded as temporary and uncertain palliatives, so long as no attempt is made to reduce the disease among the animals themselves." This sentence is the keynote to useful legislation. To protect man against a contagious disease of animals, the logical plan is to control infection at its source—"to reduce the disease among the animals themselves." A good illustration of how this can be done is afforded by the success which has attended Mr. Walter Long's well sustained effort against rabies in dogs—with the consequent disappearance of hydrophobia in man.

To protect human life against tuberculous meat and milk it is not sufficient to wait until disease has so nearly reached its goal as when it is in the hands of butchers and cowkeepers. Safety requires that the first effort should be to prevent it ever arriving so near the human stomach.

Scheduling Tuberculosis in the Animals Diseases Act.—The first step in providing for legislative control of a disease in animals is to schedule it. When scheduled it becomes "a disease" under the act, and further provisions may be added. That tuberculosis should be scheduled is the opinion of the whole veterinary profession. It was recommended by the Departmental Committee 11 years ago. This step need not be accompanied by any further regulations to do inestimable good. At present the regulation of cow-sheds depends chiefly upon the cow-sheds' and dairies' order, one clause of which refers to the "Existence of disease among cattle," and provides that "if at any time disease exists among the cattle in a dairy or cow-shed, ... the milk of a diseased cow therein shall not be used for human food." This would seem to afford all the protection necessary against tuberculosis. But the clause is a useless one, because the Act does not define tuberculosis as "a disease." Two or three other affections of cows which are not transmissible or dangerous to man are "diseases," and the milk from such animals must not be sold. The greatest danger to milk from animal disease is tuberculosis, but this is untouched by the cow-sheds' and milk-shops' order. If the Board of Agriculture were to schedule tuberculosis under the Animals Diseases Act, no diseased cow could remain in a shed supplying milk for human consumption. Here is the means for the protection of man ready at hand—a stroke of the pen could bring it into action—but the Board of Agriculture make no move, while 70,000 deaths from tuberculosis are registered annually. Such fatuous indifference is inexplicable. If tuberculosis were scheduled under the Animals Diseases Act, nothing more would be required to enable the medical officer of health to guard human beings against a tubercle-polluted milk supply.

This first step could be made without imposing on agriculturists the slightest restraint without interfering in the smallest degree with healthy stock or with any diseased animal outside of a cow-shed. Great as would be the good attained by merely making tuberculosis "a disease" under the Animals Diseases Act, I should not propose to limit the action of the Board of Agriculture to this one essential step. There are regulations which must be enforced for the protection of animals as well as for man.

Notification of Udder Disease in Cows.—One of the recommendations of the Royal Commission is that compulsory notification by the owner of all udder disease in milk cows should be enforced. This is very necessary, because official inspectors cannot attend every day, and udder infection must be detected in the initial stage. The disease develops rapidly and requires attention at the earliest moment if contamination of milk is to be prevented. The owner and his servants have daily opportunity to detect anything amiss, and they therefore may well be required to notify the danger immediately it is discovered. As I have said before, the Royal Commission cut down their recommendations to the irreducible minimum. Had they not done so, they would never have insisted upon the notification of udder disease, while leaving unnoticed generalized tuberculosis, which may not affect the udder, but which implicates every other part of the body. Cows suffering from generalized tuberculosis are quite as common in cow-sheds as those affected with tuberculous udders. From them there is a constant escape of tubercle bacilli in the excreta and in the sputum. The front of the stall in which su h cows stand is plastered with half masticated food, mucus, and sputum, while the tail and udder of the animal are fouled by the bacillus-laden excreta. Even for human safety, generalized cases of tuberculosis in cow-sheds should be included with udder disease for notification. When we take a wider view and grant that some control of disease among animals themselves should be enforced, the question arises why disease should be notified in the udder and not in oxen? If compulsory notification of disease in one gland and one animal is advisable, why not extend the requirement to include all clearly distinguishable tubercular disease in cattle? No disease has ever been scheduled in the Animals Diseases Act without compulsory notification being the very first regulation enforced. Curiously enough the Departmental Committee of 1888 declined to recommend compulsory notification. The reason they gave for this omission was, "That the disease might exist and yet show no signs of its presence." The difficulty of diagnosis existed in 1888, but tuberculin has now rendered it possible to diagnose every case. The reason which ruled the committee no longer exists, and we may infer there is no other objection to compulsory notification. But even in 1888 the recommendation of the committee was inconsistent with the course adopted with other contagious diseases. Hundreds of cases of pleuro-pneumonia in cattle and of glanders in horses then existed with no sign of their presence. Those two diseases required compulsory notification by the owner, under pain of fine or imprisonment for neglect; but of course no man was ever punished for not notifying a case he could not detect. No one now proposes to ask owners of stock to do impossibilities and no one proposes to seize or slaughter those cases which can only be detected by the aid of tuberculin. What is necessary is the notification of clearly diseased animals in cow-sheds or wherever they exist.

Inspection of Meat, Milk, and Cow-sheds.—The danger from meat is not so urgent as that from milk. If local authorities put in force all the powers they possess, very little harm from tuberculosis in animals would result from meat. The worst meat is now smuggled into shops, evasion of inspection is deliberately carried out, and no respectable butcher has anything to do with it. The most effective method of protecting the public against such meat is not by expensive abattoirs and an army of inspectors, but by making it worth the while of the owner of stock not to sell diseased animals, but to report their existence to the authorities, who would then seize and compensate. Another method of protecting the public is to enable the butcher to protect himself from loss by giving him a claim on the man who sold him a diseased animal. So far as tuberculosis goes, the whole danger of infected meat would be better controlled by scheduling the disease in the Animals Diseases Act than by any other course.

As to milk, the Royal Commission proposed inspecting and testing. Every precaution and every check would be placed on tuberculous milk by the action of the cow-sheds' and dairies' order provided its regulations were made potential by the inclusion of tuberculosis in the Animals Diseases Act.

The inspection of cow-sheds is now undertaken by sanitary officers and medical officers of health. All that the Royal Commission require further is the inspection of the cows by veterinary surgeons. This also would be effected if tuberculosis were scheduled. The inspection suggested by the Royal Commission is of course useless unless provision be made for seizing and removing diseased cows.

Slaughter of Diseased Animals.—The Royal Commission said nothing of the seizure and slaughter of diseased animals, but those measures are implied by their recommendations for inspection of milk, and for notification of udder diseases. It is evident that the discovery of diseased animals would be useless unless they were removed. To compel a dairyman to kill diseased cattle at his own cost, by stopping his business until he did so, would be an indirect meanness without precedent. I conclude the Royal Commission would wish local authorities to have power to remove and slaughter all dangerous animals in cow-sheds. The Departmental Committee unanimously advised slaughter of diseased animals and payment of compensation. Here again we see that if the Board of Agriculture would schedule tuberculosis, and deal with it as they have dealt with other contagious diseases, they would only be adopting what the Royal Commission and the Departmental Committee both recommend.

Compensation for Slaughter.—It is hardly necessary to offer any argument in favor of paying compensation to an owner for the seizure of his property for the public good. For more than thirty years the precedent has obtained of paying compensation for the slaughter of animals under the Animals Diseases Act. That a new departure should be made in the case of tuberculosis requires some reasons stronger than have yet been formulated. The owners of animals have been taught by previous experience to look to government for assistance as well as for measures of confiscation. Authorities have found it easier, more effective, and less expensive, to pay the owner for his co-operation in notifying disease and isolating infectious animals than to refuse compensation while trusting to constant inspection and compulsion for the detection and control of disease. Liberal compensation has been found by the Privy Council and by the Board of Agriculture a necessary and expedient corollary of the compulsory slaughter of animals. Compensation is of course only partial, and the owner of stock is always a heavy loser, even when he receives the most liberal compensation.

Seizure of Diseased Animals.—This was advised by the Departmental Committee whenever animals were in such a position as to be likely to spread disease to other animals, as at fairs and markets, or on roads or during transit. The Royal Commission would only advise seizure where danger to man existed. If we are to avoid limiting preventive efforts to what the commission called "temporary and uncertain palliatives," seizure of all diseased animals likely to injure man or spread disease should be adopted. Power to seize animals away from home presupposes some regulations against movement of diseased cattle, and such regulations have always formed part of any scheme for the suppression of scheduled diseases.

Use of Tuberculin.—I accept as most valuable the recommendation of the Royal Commission that the Board of Agriculture should supply to any stock-owner who desired it a gratuitous testing of his stock. As the acceptance of the test is purely a voluntary act, the stock-owner cannot object to conditions that he shall separate all the diseased from the healthy and not sell those which are infected except for slaughter. These conditions, though fair, are likely to be so troublesome to many stock-owners that I fear little request for the tuberculin test would follow its establishment by the Board of Agriculture. Cow-keepers would be well advised to accept it if the opportunity occurs, still more willingly should breeders hold out their hands for it. The voluntary use of tuberculin, whether the test be applied by authorities or by private veterinary surgeons, puts the owner in a position of command over the disease. He learns which animals are diseased and is able to separate them from the healthy stock and so prevent further spread of the plague.

The compulsory use of tuberculin should be provided for in some cases if the recommendations of the Royal Commission or of the Departmental Committee are given practical effect. The cases I refer to are those where the inspector is doubtful as to his diagnosis. These doubtful cases have always been a source of trouble, and half the quarrels of stock-owners and the officials carrying out the provisions of the Animals Diseases Act are traceable to disputed diagnosis with consequent delay in action and increase of trouble and cost. Tuberculin would assist to a correct diagnosis in a few hours. Udder diseases are many, and to differentiate every case of tubercular disease from induration due to non-specific causes is impossible. Tuberculin produces a local reaction in all affected organs, and so renders diagnosis of tubercular udder disease certain.

The various measures I have now discussed have all been recommended either by the Royal Commission as necessary to protect man from danger, or by the Departmental Committee to control disease among stock. The government has ordered two select bodies to take the best evidence they could obtain and then to report what they considered necessary for the control of tuberculosis in animals. These authoritative bodies have reported, and from their published recommendations we may safely compile a complete scheme. It would be as follows:

Tuberculosis to be scheduled in the Animals Diseases Act.
Compulsory notification to be enforced.
Inspection of meat, milk, and cow-sheds to be carried out.
Movement of diseased animals to be regulated.
Slaughter of visibly diseased animals to be enforced.
Compensation to be paid to owner for slaughter.
Seizure of diseased animals in markets or during transit.
Power to use tuberculin in doubtful cases to be given to authorities.
Offer of gratuitous tuberculin test to all stock owners, subject to isolation of all infected animals.

Our administrators know perfectly well what their trusted advisers have said, and what ought to be done. The loss from tuberculosis is 70,000 persons and 40,000 cattle every year. Is this not sufficiently serious to demand action? It would be absurd to suppose there was any doubt. Legislation is inevitable, and it must follow the lines sketched by the authorities I have quoted. The hesitation of government to adopt legislative interference is due simply to fear of movement until the public, or a majority, are convinced of the necessity. The public are being rapidly educated. The trade interests most directly concerned will do well not to assume indifference, but to take an active part in promoting the public weal, at the same time that they defend themselves against any injustice.

There is one question that all sensible men endeavor to answer, before commencing any scheme, viz., what will it cost? The control of tuberculosis among animals is not a small matter, and no scheme of legislation with this object has the slightest chance of adoption by a government department until the heads are satisfied of a probability of success, commensurate with the cost.

The State of Massachusetts, and the kingdom of Belgium, have shown by failure the impossibility of stamping out the disease by such radical measures as have been successful with some other animal plagues. If we accept the estimate that 20 per cent. of 4,500,000 of cattle are infected, and then assert that all these animals must be slaughtered and partially paid for, we enter on an undertaking that neither the owner of stock nor the taxpayer would approve. There is no necessity for such wholesale slaughter. The majority of infected cattle are not infective to others—they are neither dangerous to man nor other animals, and their slaughter would be a wicked waste. Only the visibly affected are dangerous, and their number does not exceed 40,000. This estimate would include every animal whose carcass is wholly unfit for human food, and every cow whose milk is unfit for consumption. The slaughter of these would be a loss to the owners, but it would be a public benefit, and it is expedient and just that the public should share the loss.

I suggest that local authorities should pay as compensation £2 per head for all compulsorily slaughtered, of a value not exceeding £8; and a sum equal to one-fourth the market value of all others seized—but no animal should be valued at over £24. Any salvage on carcasses, minus the cost of removal and slaughter, should be repaid to the owner.

The payment of £2 as compensation for miserable animals that are a danger to man or to other stock may seem an illogical proceeding, but unless some such inducement is offered, many of them would be sold to the lowest class of butcher and find their way into human food. A payment of £2 per head would make it worth the while of the owner not to evade reporting to the authorities, and so the existence of disease would become known with greater expedition. Infected premises once recognized could be supervised in such a way as to assist the owner and protect the public.

The difficulty of doing justice to the butcher might be met in another way. In any Act of Parliament dealing with the subject a clause might be inserted enforcing a warranty by the vender of freedom from tuberculosis, whenever a butcher bought cattle and distinctly stated he was buying for the purpose of slaughter for human consumption. Such a clause would take from the butcher any claim for compensation, would protect the public by eliminating any reason for hiding disease, and would lay the burden upon his seller who is able to protect himself by testing the stock before going to market. This compulsory warranty would be limited to a period of eight or ten days.

The Royal Commission used as an argument against the payment of compensation the evidence given it that butchers very seldom had much loss, and that the few cases occurring might easily be met by mutual insurance. If the argument has any basis, the fact may be used to show how slight the burden of my proposed

warranty would be on stock venders. The breeders and feeders are certainly more to blame for disease and its non-detection than butchers; they should, therefore, be held more responsible. By eliminating the butcher's claim for compensation measures of control are simplified, because we then may deal with all stock and all claims under the Animals Diseases Act, which would provide assistance to the owners of stock and compensation for all notified disease.

Compensation at the rate of £2 for all animals below the value of £8 and compensation at a higher rate on all over that value would probably reach a cost of £100,000 in the first year and a constantly decreasing sum every year afterward until no disease existed. This is less than is now paid every year for the attempts to stamp out swine fever.

For this payment, what should we receive? A guarantee against human infection from animals, and a gradual but rapid suppression of disease among stock.

I have now laid before you arguments in favor of legislative action. I have shown what danger and loss the disease causes. I have offered an estimate of the probable cost of proper control.

I hope I have been able to prove that voluntary effort is insufficient, and that the protection of human life will be most effectively undertaken by measures which apply to all animals, and not to those only which are in the hands of butchers and cowkeepers. The cheapest and best method is the one which is effective; the most costly is that which the Royal Commission well described as "temporary and uncertain palliatives."—Journal of the Society of Arts.

INSTRUMENTS FOR MEASURING SMALL TORSIONAL STRAINS.*

By E. G. COKER, B.A., B.Sc.

THE advances made within recent years in the scientific testing of engineering materials have caused great attention to be paid to the design of instruments for measuring small strains. By far the greater number of such instruments have been devised for measuring the small strains of extension or compression in bars subjected to a direct pull or push, and but little attention has been paid to instruments for the use of engineers in the measurement of the small strains in a bar subjected to twist.

The object of the present paper is to describe two arrangements of apparatus intended for use in engineering laboratories and testing houses for measuring such strains and for the determination of the modulus of rigidity.

Each instrument is wholly supported by the test bar, being secured thereto by screws, which grip the bar at two transverse sections separated by a known interval, and the relative angular displacement between these two sections is measured directly. The instruments are adapted to measure both large and small strains, and are self-contained, while they can be used in a horizontal, vertical, or inclined position.

One form of the apparatus is shown by Fig. 1, and consists of a graduated circle, *A*, mounted upon a chuck plate, *B*, provided with three centering screws adjusta-

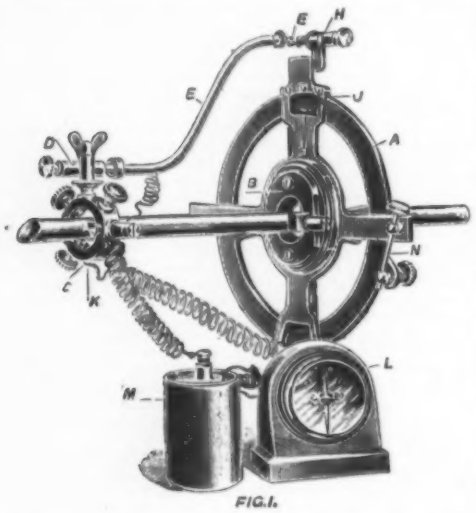


FIG. 1.

ble by hand. A ring, *C*, secured to the test bar by set screws at a known distance away, carries a swivel arm, *D*, in which slides a tube, *E*, so that the contact ball, *F*, at its outer end can be brought into position touching the center of the faced end of a screw micrometer gage, *H*, provided with a divided head. This micrometer screw is mounted upon a vernier plate, *J*, of the graduated circle, and can be clamped in any position, the final adjustment being effected by a screw, *N*.

A silk-covered wire connects an insulated binding screw, *K*, upon the ring with the contact ball, and this wire is joined up in circuit with a simple form of galvanometer, *L*, and cell, *M*, to a second uninsulated binding screw on the ring. If the contacting pieces are touching, a circuit is completed through the test bar, and the galvanometer needle is deflected. If now a twisting movement is applied to one end of the test bar, the contacting pieces are separated, and the micrometer screw must be advanced until the circuit is again completed, as indicated by the galvanometer needle. The number of divisions through which the screw has been turned affords a measure of the angular displacement, and it only remains to calibrate these readings in terms of angular measurement. The calibration is effected by reference to the graduated circle and vernier plate.

The micrometer screw is set tangentially to the radial arm, and, therefore, its indications are nearly proportional to the tangent of the angle moved through; but if the faced end of the screw is always maintained at or about its central position, the error introduced by taking the readings as directly proportional to the angular displacement is relatively small compared with the quantity under measurement, and may be neglected. To calibrate the instrument, it is, therefore, only necessary to measure the number of divisions corresponding to a small angular displacement of say 10′, and this is easily accomplished by setting the instrument in position with the circuit complete, and afterward following up a known angular displacement of the vernier plate by the micrometer screw.

A single form of detector galvanometer, in circuit with a single dry cell, has been found to be a convenient arrangement for indicating when contact takes place, and the feeble current required does not injure the contacting surfaces. It is essential that the graduated circle be set accurately upon the bar, with its plane perpendicular thereto, and its center coinciding with the longitudinal axis of the bar. An arrangement has been devised to effect this, consisting of two similar and equal clamp bars, the eyed ends of which take over outwardly projecting cones arranged diametrically upon the chuck plate and ring. Each main piece has one degree of freedom with respect to the clamp bars, and, therefore, two degrees of freedom with respect to the other; these degrees of freedom are suppressed by projecting plates fitting against corresponding projections on the main pieces, and this connection makes the apparatus a rigid whole. The bar is now inserted and the screws adjusted by hand as accurately as possible. The clamp bars are afterward removed, leaving the two main pieces accurately spaced on the bar, while the graduated circle remains perpendicular thereto, and very approximately centered. The light contacting arm is then clamped in position and the bar may now be set in the testing machine. An improved clamp described with reference to the second form of apparatus may be used instead of the arrangement described above, and the hand-operated chuck plate may be replaced by a form of self-centering chuck described below. An example of tests made with this apparatus is given below. The test bar was adjustably secured at one end and a balanced lever of fixed length secured upon the free end and hung from the arm of a scale beam. The load was applied by placing equal weights in the suspended pans of the balanced lever and scale beam, so that bending movement was as far as possible eliminated. Before making a reading, the torsion arm was brought to a horizontal position by aid of a spirit level. The mean of the calibration tests gave 18·6 divisions of the micrometer screw as corresponding to an angular displacement of one minute of arc. Turned bar of Bessemer steel, length under measurement = 10·25 inches, diameter = 0·747 inch, torsion arm = 15 inches, a constant.

The second form of apparatus differs from the preceding in employing a reading microscope to observe the relative angular displacement of a radial line upon the vernier plate. The edge of a thick wire is a very convenient line for observation, and has been used with notable success in an extensometer designed by Prof. Ewing. (Proc. Roy. Soc., May, 1895.) The instrument is shown by Fig. 2, in which *A* is the graduated circle mounted upon a chuck, *B*, and furnished with a vernier plate, *J*, an arm, *O*, of which carries a wire, *P*. A reading microscope is carried in the sleeve, *R*, of an arm, *S*, mounted upon the short cylinder, *C*, which latter is gripped upon the test bar by screws. The reading microscope has an eye piece, *T*, provided with a

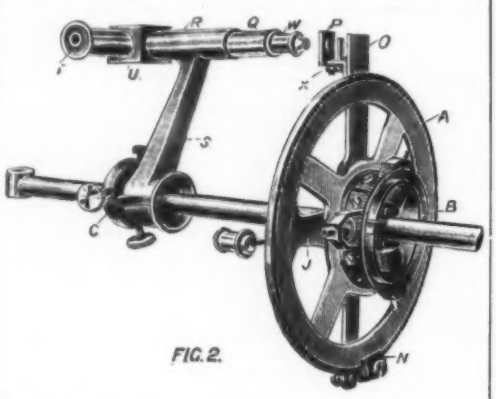


FIG. 2.

glass scale, and a right-angled prism, *U*, is interposed between this and the objective, *W*, so that readings can be easily taken. The tube, *Q*, is free to slide or rotate in its guide, *R*, but in order to readily focus the wire this latter is carried in a frame, *X*, pivoted upon the vernier plate, *J*, and adjusted by a screw.

The microscope arm, *S*, is secured to the cylinder, *C*, by a divided collar, the two halves of which are pivoted on one side and the free ends are clamped by screws. If it is desirable that the telescope be turned round or released altogether, the screw may be thrown out of engagement. Since the difference between an arc and its corresponding chord is an infinitely small quantity of the third order when the arc is an infinitely small quantity of the first, the readings of the microscope scale may be taken as directly proportional to the angular displacement, and the calibration is effected by mov-

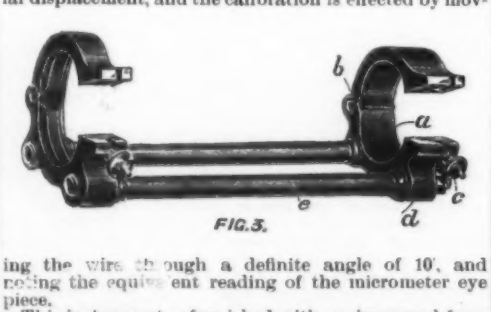


FIG. 3.

ing the wire through a definite angle of 10′, and noting the equivalent reading of the micrometer eye piece.

This instrument is furnished with an improved form of clamp—Fig. 3—consisting of a pair of divided collars, *a*, the halves being pivoted together at *b* and secured by nuts, *c*. The collars are wedge-shaped in radial section to engage with corresponding wide-angled grooves upon the chuck plate and cylinder, only the angled sides being in contact, so that the collars are readily fixed when required. The lower halves, *d*, of the divided collars are connected by one or more distance pieces, *e*, so that when the former grip their respective grooves each piece has one degree of freedom with respect to the clamp, and this can be suppressed by a pin or by the frictional grip of the collars, thereby causing the parts to act as one rigid whole for setting the instrument on the bar. The graduated circle of this instrument is carried by a self-centering chuck of somewhat novel form, and a section through this is shown

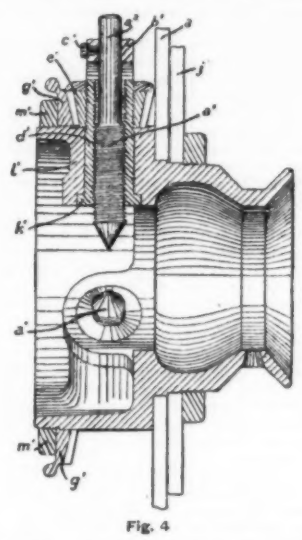


Fig. 4

by Fig. 4, while a perspective view of the arrangement is shown by Fig. 5.

There are three centering screws, A^1, the outer cylindrical ends of which are supported in guides, B^1, and prevented from rotating by pins, C^1, engaging with slots, S^1, cut in the screws. The screws work in rotating nuts, D^1, provided with bevel pinions, E^1, gearing with a hand-operated bevel ring, G^1, so that all the screws are advanced or receded together. An additional pinion, H^1, is provided, operated by a key fitting on its squared spindle, J^1, so that the screws are firmly gripped upon the bar. The inner ends of the nuts have a collar bearing, K^1, so that the stresses are borne by the body, L^1, of the chuck, and the bevel ring is prevented from seizing by bearing plates and an adjustable ring, M^1, at the back. This bevel ring can be slid back to allow any screw to be separately adjusted.

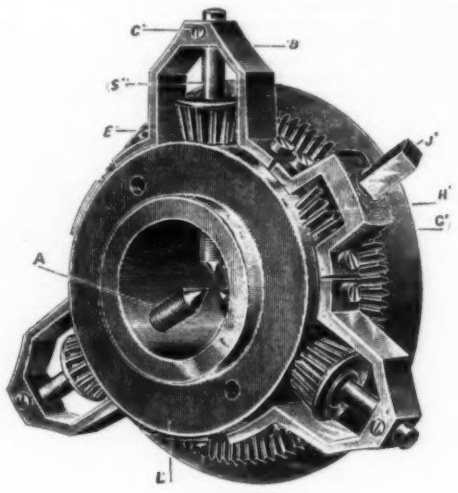


FIG 5.

Other modified arrangements of the chuck have been tried, in which the guide pins have passed bodily through slots cut through the inner ends of the screw, and the screw pairs have been inverted, but these modifications have not answered well.

An example of tests made with this form of apparatus is appended, the same Bessemer steel bar being used: Mean value of calibration test, one minute of arc corresponds to thirty-six divisions of scale. Length under measurement, 8 inches; diameter, 0·747 inch; torsion arm, 15 inches, a constant:

Load, Pounds.	Reading.	Differences.
0	800	41
1	759	41
2	718	41
3	677	41
4	636	40
5	596	41
6	555	42
7	513	42
8	471	41
9	430	41
10	389	40
11	349	40
12	309	42
13	267	42
14	225	42
15	283	40
16	143	40
17	103	40
18	62	41

* British Association, Section G.

And we have for this test bar C = 11,850,000 pounds per square inch.

A second test gave very approximately the same result. Angular displacements of one inch can be measured with this form of apparatus. As the overhanging arm carrying the microscope is necessarily heavy to afford the requisite stiffness, the length under measurement is limited. For the purpose of making the angular displacement visible to an audience, a magnifying arrangement is used, consisting of a tilting mirror supported upon a tripod. Two legs of the tripod are supported by a hole and slot carried upon the vernier plate, and the third leg is supported upon a plane attached to the other main piece. The spot of light reflected from the mirror is caused to move over a fixed graduated scale, and the angular displacement is thereby made visible.

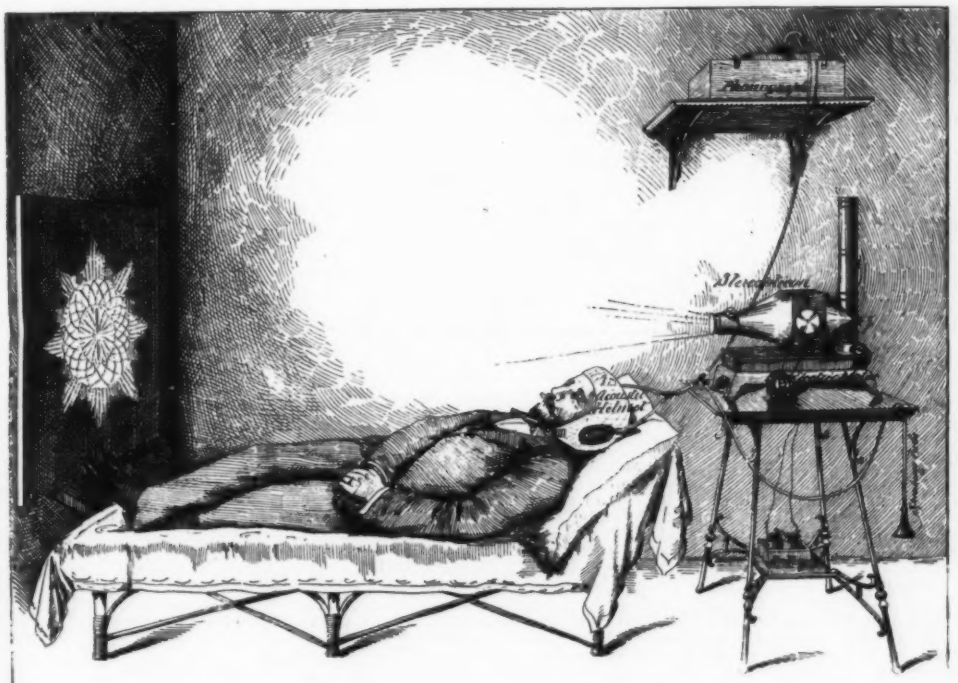
We are indebted to The Engineer, of London, for the article and illustrations.

THE USE OF MUSICAL VIBRATIONS AND CHROMATOSCOPIC FIGURES—A CONTRIBUTION TO THE THERAPEUTICS OF EMOTIONS.

IN a recent number of The Medical Record there is an important article by J. Leonard Corning, A.M., M.D., of New York, entitled "The Use of Musical Vibrations Before and During Sleep—Supplementary Employment of Chromatoscopic Vibrations—A Contribution to the Therapeutics of the Emotions."

The method of treatment outlined is so novel and interesting that we give an abstract of certain portions of Dr. Corning's paper. To make a just estimate of the propositions constituting the burden of the paper entails some acquaintance with the psychology of the affective life. The feeling of the waking state, the psychology of sleep and of dreams are treated, then finally the author comes to his method of employing musical vibrations during sleep.

In the first place, he made a kind of hood of canvas



DR. CORNING'S METHOD OF TREATMENT WITH MUSICAL VIBRATIONS AND MOVING SLIDES.

or soft leather, which enveloped the whole head, extending forward over the ears, so that the face alone remained uncovered. Just at the point where the cap rests upon the ears, he caused the material to be cut, and a kind of metallic saucer was then placed over each ear and its margin, broadly flanged and perforated for the needle, was sewed to the edges of the opening. Each saucer was provided with a hollow metallic nipple, situated just above the ear and communicating with the inclosed ear space. A piece of small rubber tubing twenty-five feet long was attached to these two nipples by a short bifurcation. The other end of the tube was connected with the reproducing mechanism of an Edison phonograph.

In spite of obvious imperfections, the phonograph presents incontestable advantages as a producer of powerful musical vibrations. Persons who suffer habitually from mental and physical atony in the morning, who are capable of little or no exertion before midday, and whose constant complaint is that they derive little or no good from sleep, no matter how long prolonged, often experience a decided revival of vigor if subjected to the vibrations of the phonograph during sleep. Dr. Corning's experience is that harmony is more effective than melody in his vibratory plan of treatment, and for this reason selections from Wagner's compositions render excellent service. Arpeggios and minor chords are likewise exceedingly effective. The simple appliance just described possesses many advantages; the least of these is its ability largely to exclude disagreeable or disjunctive noises. This is rendered possible by the careful padding of the edges of the metallic saucers where they press upon the cranial bones. The subject, as a result of this arrangement, is effectively screened from intrusive elements of environment whose presence could not but materially diminish if not wholly inhibit the benefits otherwise to be derived from the treatment. While soft, musical vibrations, far from interfering with sleep, tend rather to induce it, there is no denying that the presence of the cap is sufficiently unusual to retard sleep at first. This difficulty may be readily overcome by giving the patient some appropriate hypnotic, fifteen or twenty minutes before retiring, or his power of attention may be exhausted by causing him to look fixedly at a bright object rapidly revolved and illuminated by a light so screened as to leave all else in complete obscurity. A disk of tinfoil rotated by clockwork behind a dark sheet of cardboard, perforated by an orifice sufficiently large to disclose about a square inch of tinfoil, answers every purpose.

The method to which he gives preference is the projection of chromatoscopic images, which possesses the advantages of the foregoing methods as far as fixing the attention is concerned, and has the added virtue of making a much more powerful appeal to the affective life of the subject.

The subject is placed upon a low divan and the acoustic hood is applied; a tent-like arrangement shutting in the divan, both above and at the sides, excludes the light completely. At the foot of the dark chamber thus simply constructed is a white screen stretched upon a frame. Outside of the curtained inclosure is a small stereopticon of short focus. Only the tube of the instrument protrudes through a small aperture in the drapery. Various chromatoscopic slides may be successively introduced into the slot of the lantern, and it is evident that accurate focalization makes it possible to project many-hued images upon the little screen at the foot of the couch—images whose ever-changing form and capricious beauty hold the attention with an ineffable enchantment. A small electric motor rotates the mechanism of the slide.

Harmonic vibrations are derived from an Edison phonograph placed in communication with the ear-pieces of the acoustic hood. Most of the music to be had in the shops is quite worthless for the purpose, but special cylinders can be made. The phonograph should always be operated behind closed doors in an apartment adjoining that occupied by the subject. The communication between the hood and the phonograph may be had by passing the conducting tube through the cut hole. By using two phonographs it is possible to avoid any break in the continuity of the harmonic vibrations. With the use of the apparatus which we have described, depressive ideas lose their ability to a certain extent to engender moods of corresponding somberness. In order to speak to the subject without removing the acoustic hood, a small speaking tube is connected with the phonograph tube, as is shown by the illustration. Suggestions made by way of this tube while the mind is engrossed by the sounds and colors have a semi-hypnotic effectiveness. Dr. Corning has submitted a number of his patients to the effects of musical vibrations for many hours during many consecutive nights at the time when he had every reason to believe that unconsciousness was most complete, and after prolonged and numerous trials he had become convinced that here, in this untrodden field, we have spread before us a host of new opportunities, not of theoretical acquisition merely, but of substantial achievement in the realm of the tangible and useful.

LYDDITE—THE NEW EXPLOSIVE.

PROBABLY one of the most interesting features of the Omdurman campaign, from a military standpoint, was the great success achieved by the lyddite shells, which, used for the first time in actual warfare by the British army, proved that lyddite is the best explosive as yet discovered for use in shells. It is the object of the present article to give a short description of this substance, which is destined to play an important part in the wars of the future. Lyddite is only a variety of picric acid, which has been melted and allowed to solidify, thereby becoming denser. Melinite, recently introduced into the French army, is also another form of picric acid; indeed, most of the so-called "new" explosives consist of this substance in one or other of its forms, disguised by different names. The history of picric acid as an explosive is remarkable, and furnishes a striking example of how great discoveries may frequently result from accident. Picric acid was discovered in 1771, and for more than a century was used as a dye for wool, silk, and leather, without its explosive powers being suspected. Some ten years ago a fire occurred at a chemical work in Manchester, and spread to a shed containing a quantity of this acid. Being melted by the heat, the acid flowed until it came into contact with a quantity of litharge stored in the same building. A terrible explosion followed, and subsequent investigation revealed the fact that under certain conditions picric acid behaved as a powerful explosive. Further experiments have made clear the necessary conditions; and at the present time picric acid bids fair to outrival all other explosives for the purpose of filling shells.

Before proceeding to describe the manner in which this body is caused to liberate its explosive power, it will be advisable to give a brief account of its manufacture and common properties, in order that the sequence may be made clear. Pure phenol, or carbolic acid (the common disinfectant obtained from coal tar), is placed in a vessel with an equal amount of strong oil of vitriol (sulphuric acid), and the temperature raised to the boiling point of water. Strong nitric acid (aqua fortis) is then allowed to flow into the mixture, after which the whole is cooled, leaving a solid mass of yellow crystals in the vessel. The crystals are filtered and drained, and afterward washed with cold water—when the residue is pure picric acid. The crystals so obtained have an intensely bitter taste, and for this reason have been largely employed on the Continent for the adulteration of beer. If handled, picric acid stains the fingers a golden yellow. If heated gently, it melts quite tranquilly, and may be poured from one vessel to another. If strongly heated, it chars with a slight fizzle; if hammered on an anvil, no detonation occurs, as in the case of most other explosives. A cursory examination, such as the foregoing, gives no indication of its latent powers, and it is therefore a matter of little wonder that they should have remained undiscovered for more than a century. . . . .

The shock necessary to explode picric acid in all its forms is furnished by a class of bodies known as "detonators." These are sensitive bodies which explode with great violence; and if placed in contact with a large mass of picric acid, the shock to which their explosion gives rise causes the whole charge to detonate, an extremely small quantity of the detonator sufficing to set into action an indefinitely large quantity of the acid.—Chambers's Journal.

HOW DYNAMOS ARE SOLD.

THERE is, perhaps, no commercial business so susceptible to ingenious twisting of facts as that which has for its object the sale of electrical apparatus, and this may be well illustrated by the common practice of a good dynamo salesman. Let us suppose, for instance, that we have a capitalist who wishes to install in his office building a 500-light dynamo. Relying on his own business shrewdness, which has stood him in stead for many years, he writes to a number of dynamo builders, and is soon surrounded by their agents, who are anxiously bidding to secure the contract. The various prices are submitted, each agent bidding on the nearest size which he manufactures. If the quality of the machines are equal in every case, the bids will be very close indeed, and in a measure proportional to the size of the machines. The capitalist will review the bids carefully and then talk with each of the representatives upon the merits of the machines in order to make a decision.

The lowest bidder does not need to argue very eloquently. He has the initial advantage, but it is not an infrequent occurrence that the highest bidder can readily carry off the palm. The shrewd agent will soon see that his price is high, and will admit as much to his prospective purchaser, but will say: "These other gentlemen are bidding on machines which will carry 500 lights and no more. The machine that I propose to supply you is specially designed to carry an overload of some 50 per cent. for four or five hours. The conditions of your load might be such that you will find this an extremely valuable feature. We rate our machines very liberally and allow ample margin for contingencies; for this reason we think we justly ask better prices." The prospective purchaser will take this matter very much to heart, and the chances are strongly in favor of his buying a 600-light machine disguised under the name of a 500-light machine able to carry overloads. If the agent had said that his machine would carry 600 lights, the buyer would have said, "I do not want 600 lights, 500 lights is ample;" but the idea of getting added capacity for practically the same money is most attractive.

Again, we have the case of the purchaser who has pretensions to electrical knowledge. In no case is the old proverb, "A little learning is a dangerous thing," more forcibly illustrated. The chances are ten to one the agent knows about as much of electricity as the purchaser, and the way they exchange high-flown technical terms to their mutual mystification is amusing in the extreme. To illustrate, an actual case in point may be mentioned—an instance where a certain man had been considering the relative merits of several bids for a dynamo machine for his factory. Some of the agents had been talking knowingly of losses, efficiency, rise of temperature, hysteresis, and other matters relative to the performance of a dynamo. The purchaser gathered that these various qualities were desirable qualities, arguing to himself if they were not, the agents would not have mentioned them; or more probably obtaining his idea from inference rather than argument. When the next bidder appeared and asked for an audience, he proceeded to talk of temperature rise, hysteresis, and like matters. The agent, likewise, at once inferred that these things were much to be desired in a dynamo. He was of German extraction, and he communed within himself, "If Thomas Huston and Edison haf hysteresis in their dynamos, ve must haf some too." He succeeded, however, in arguing so well that he closed the contract, one of the inducements being that he should write to his firm and stipulate particularly that in the dynamo to fill this order there should be an exceptional amount of hysteresis.

Again, we are told of a case which seems hardly worthy of credence, but is said to be an actual fact—that of two bidders, one making a proposition on an

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iron machine and the other submitting a price on a machine with a cast steel frame; the former secured the contract, arguing that his machine was the heavier by some 400 pounds, and therefore more substantially built, and was not starved of iron or copper, and there was plenty of material there to stand the load, etc.

A good agent will make talking points out of nothing, advantages out of disadvantages, and virtues out of necessity, and will carry off a contract at a high price, while a man of mediocre business ability with a better machine and scrupulously careful of what he says, will fail to secure the order. Capitalists do not seem to appreciate cautious, conservative opinions. They must be superlative or they are adverse. Truly said the great showman: "The American public likes to be fooled," and the capitalist most of all. He will not invest his money unless the facts are highly colored, even to misrepresentation.—American Electrician.

ELECTRIC STREET RAILROADS IN ENGLAND.

HERETOFORE the cities of Great Britain have been among the most backward of any cities of the leading nations of the world in the matter of street railroads. A great change is taking place, however. There has recently appeared in London a trade journal devoted to street railroads and kindred subjects. Undertakings are in progress in the principal cities of the kingdom for the establishment of the most improved systems. In a large number of cases, these enterprises are a feature of a remarkable movement which has been quietly but irresistibly getting control of the government of the chief cities, and may be described as "municipal socialism"—that is, the ownership and operation by the municipality of certain enterprises which by their very nature must necessarily be more or less monopolistic, such as street railroads, electric and gas lighting plants, the water supply, and telephones. In some instances, however, this municipal socialism extends beyond this classification. In several cities in Great Britain the municipal corporations build dwellings for workingmen and even run hotels; in others they erect and operate magnificent mineral and Turkish baths.

Within the last two years there has been a widespread agitation in Great Britain against the awarding of public contracts to foreign concerns. This sentiment has been particularly aroused by the bringing over of workmen from the United States to perform public contracts. Were it not for the fact that for the last eighteen months labor generally has been plentiful here, with fair wages, this opposition would probably have made itself even more manifest. Certain industries, particularly those relating to iron and steel, are very busy in Great Britain now, as there is an accumulation of orders which had to be postponed because of the recent engineers' strike. It so happens that the movement described above for the "municipalization" and improvement of street railroads and the construction of electric light plants, etc., became active throughout Great Britain contemporaneously with the labor troubles of last year and the year before. The result was that the British manufacturers were placed at a great disadvantage when it came to making bids for these public contracts, and this applied both to prices and the time in which the work could be turned out. Some municipalities issued advertisements for tenders and gave the contracts to the lowest bidders, even though they were foreign concerns, and a number of American contractors and manufacturers reaped the advantage. The Germans also got a number of contracts for steel rails. Then the agitation arose among the workingmen against giving contracts to foreign concerns, and pressure was brought to bear upon the councilmen and aldermen of the various municipalities.

Nearly two years ago, the corporation of Liverpool purchased the street railroad system for about $3,000,000, with the intention of substituting electricity for horses, the details being left to a committee of the city council. It was decided to build an experimental line, double track, from the center of the city for a distance of about 2½ miles. Although little was publicly said about the matter, the committee was confronted at the outset with the opposition to foreign competition; yet, several of the most active of the promoters of the improvement were pronouncedly in favor of a free field and no favor. The first success of the opponents of foreign competition was in the defeat of the proposition to employ an American supervising expert. Bids were obtained for steel rails from a number of firms in England, the United States, and Germany. It was discovered that the English bids ranged from 10s. to 30s. ($2.43 to $7.29) per ton more than the American and German bids. It was claimed that the American and German bids did not fill the conditions exactly as to height and shape of the rail. So the contract for the rails was awarded to a London concern. There was no stipulation as to material, but the distinct understanding was that English rails should be supplied. It turned out, however, that the English concern sublet the contract to a German firm, and all the rails which have been laid on the experimental line, just completed, are marked "Made in Germany." The excuse given by the London firm was that, owing to the accumulation of orders on hand, they could not meet the contract in time with English rails.

Recently the committee in charge gave out to a Leeds firm a contract for the rails for an extension of the experimental line. The price to be paid is £7 ($34) per ton. The chairman expressed satisfaction that the rails would be of English manufacture.

So far as the street cars were concerned, the municipal committee found that no English firm could turn them out in time, and so they were compelled to go abroad for the experimental cars. About fifty have been purchased so far, half of them coming from the United States and half from Germany. Nearly all of the electric plant has come from the United States.

I have inquired with particularity from those in authority whether, in the extension of the electric street railroad system, foreign competition will be invited and accepted if the bids were the lowest and the best. I am informed that, owing to the protests of their constituents, the city council will not go abroad for any more of the work where it can possibly be done in England—and this will include the furnishing of rails, electric plant, and cars. It is better that American contractors and manufacturers should understand the situation as it really exists, and yet I believe it is worth their while to make an attempt to secure some of the work, not only in Liverpool, but in other British municipalities. Within the next few years there will be a great many million dollars spent by the municipalities over here in street railroad and electric light improvements. King's Manual of Electrical Undertakings gives the aggregate capital of the electrical companies in Great Britain and Ireland for 1898 as $426,426,120. In Liverpool alone from $5,000,000 to $7,000,000 will be spent for steel rails, electrical plant, and cars within the next two or three years. The length of the contemplated street railroad extensions is about 100 miles.

A heated discussion is going on here as to the best system of traction. The general sentiment is strongly in favor of electricity as against horses, gas, or oil as motive power. The experimental line, just completed, is the overhead trolley system. It has met with much opposition from the standpoint both of æsthetics and of safety. The committee which had the work in charge claimed that the best experts, both in the United States and on the Continent, have pronounced the conduit system a failure, and they plead that they were therefore compelled to adopt the overhead system. The probabilities are that the overhead trolley will be used in the extensions, but that the work will be more artistic and lighter than that of the experimental line. In this connection, it is interesting to note that the city council of Manchester has formally adopted the overhead trolley system as opposed to the conduit system for the reason, as given, that investigations at New York, Washington, and Baltimore had demonstrated that the former system was the cheaper and more adaptable to varying physical conditions. There are, however, several systems proposed which, it is claimed, are as cheap as the trolley system and as safe as the conduit system, without the disadvantages of either. Particular commendation is given to a new surface contact system, the invention of Prof. S. P. Thompson, of Finsbury Technical College, London, and Mr. Miles Walker, of Cambridge. This system has been tried in London, and has, so it is claimed, proved successful. A correspondent of The Liverpool Daily Post thus describes this system:

"In the roadway between the rails is laid a single row of bronze studs, which are the points of contact. The studs are about 2½ inches in diameter and are firmly screwed down into a block of concrete about a foot square. They are not at all conspicuous and rise but slightly above the general level of the roadway. The studs are 'dead' until they come in contact with a piece of iron charged with the current. As soon as the skate underneath the car touches a stud, a connection with the main is established, and the moment the contact is withdrawn the stud is again 'dead.' Thus the skate underneath the car is the medium of communicating the current to the electric motor, which is the one usually adopted for overhead traction; and the skate must always touch one stud before it leaves the other to maintain a continuous supply of current.

"The advantages claimed for this system are: The complete safety of the public, as the studs are absolutely harmless after the car has passed over them, careful provision being made in case, through some accident, the current should remain on; the studs give no trouble at crossings, as one stud will serve for two lines of tramway; they are perfectly insulated so as to resist wet, snow, frost, traffic, and time; no interruption can take place owing to the studs being covered by mud or water, and obstructions such as stone or wood are pushed aside by the skate of the tram car. In case of mishap, a few minutes suffice to unscrew the stud and replace with a new one. It will be seen that the Thompson-Walker system avoids all the disadvantages of the conduit system, as well as the unsightly effect of overhead wires, the studs being scarcely noticeable at all."

A British company has just made an offer to the London county council to place a dozen gas-propelled street cars on the South London lines, at its own expense, with the object of proving that gas cars are more efficient and more economical than electric cars. Large claims are made for the gas motor (which is a German invention, with English improvements); but a Liverpool municipal official who has investigated it informs me that it is far inferior to the overhead electric trolley system.

In London proper, owing to the narrowness of the streets, surface street railroads are, for the most part, impracticable—at any rate in the older districts of that city. There are two underground railway systems in London—the Metropolitan and the Metropolitan District—both using steam. There is now approaching completion a third underground railway, but electricity will be the motive power, and it is gratifying to state that most of the electric plant is of American make. There were recently ordered from America fifty passenger elevators for the use of underground railways in London. The London Times gives the following information as to the substitution of electricity for steam on the two old underground railway systems:

"The directors of the Metropolitan and Metropolitan District railway companies have decided to undertake at their joint cost a series of experiments prior to the introduction of electric traction on the Inner Circle lines. For this purpose, it is proposed to lay down between Earl's Court and High Street, Kensington, an electric installation adequate for the hauling of a train which shall be fully as heavy as those now running at the busiest times of the day on the Metropolitan Railway. This section of the company's line has been chosen for two special reasons: First, because the ordinary service thereon is not so frequent as that on other sections; and, in the second place, because it contains some steep gradients—as sharp as 1 in 40—which will enable the new electrical system to be tested under the severest conditions that would be experienced in regular working.

"Each company has agreed to put down the sum of £10,000 to defray the cost of the experiments, and these will be carried on, without any interruption of the present steam locomotive traffic, for eight or ten months—a period sufficiently long to demonstrate the practicability of the principle thereafter to be introduced generally on the lines of the Metropolitan and Metropolitan District railways. The contract for the experimental work has been let, and it will be executed forthwith under the direction of Sir John Wolfe Barry, the consulting engineer to the Metropolitan Company, with whom is associated Mr. W. H. Preece, the engineer in chief and electrician to the general post office.

"In the first instance, the generating station, erected on land belonging to the Metropolitan District Railway Company, at Earl's Court, will, in all respects except foundations for boilers and dynamos, be temporary in character. Two conductors are to be laid parallel between each of the lines of the permanent way between Earl's Court and High Street, Kensington, and these will be permanently available when the electric system is introduced generally on the two railways. The contractors have been instructed to build for the purposes of the experiments two motors, so designed as to form part of the permanent plant, and the train used will be similar to those now running over the Inner Circle. It is expected that the preparations for this important trial will be completed during the summer of next year."

Owing to the enormous volume of traffic, the above undertaking will probably be the largest enterprise of any kind in the world in which electricity is the motive power.

The extraordinary awakening in England in the use of electricity extends in a still further direction than that outlined above. There is a scheme under way for connecting Liverpool with the manufacturing towns within a radius of 17 miles, by light suburban electric street railroads, which in the daytime will carry passengers and at night will carry freight. Electric light and power will also be supplied to the towns. There will be a huge station at St. Helens. The company has a capital of $5,000,000. There are also organizations springing up for the encouragement of the use of electricity, steam, gas, and oil as motive power for freight road wagons.

JAMES BOYLE, Consul.

Liverpool, November 25, 1898.

GEOGRAPHIC DISTRIBUTION OF THE VERTEBRATA.*

THE lower we go in the scale of life, the wider is the distribution of the animal; as we ascend, they become more circumscribed in their areas. We find that all through the history of the animals of any particular region, from the time they first appeared, they have been struggling against other forms for supremacy—what Darwin calls the struggle for existence. The older and weaker types are continually being killed off by the stronger animals; and in the same way, wherever a new section of country is opened up for any group of animals, they will immediately spread out and occupy it, in the tendency to get away from the other forms. During the past geological history of the earth, whenever any section of land was raised above the earth's surface or any small island was increased by being raised higher in the water and a larger area made habitable by the animals, they immediately spread out to occupy this new area; and, of course, wherever any difference in climate or surroundings was found, that had an effect on the animal—they differed in accordance with their surroundings. Does some new kind of vegetable growth appear on some of the new land, the animals immediately become adapted to feeding on this, and it produces at once various modifications in their jaws. Climate, the heat of the sun, excess of moisture, all affect the color of animals. An animal, passing from a very hot, arid district, and taking up residence in a humid, well-shaded country, is, in the course of thousands of generations, influenced by this change of environment and presents a very different coloration. Marsupial mammals, like the kangaroo and the opossum, represent, with one exception, the lowest order of the mammalia, and were once very widely distributed over the land areas of the world. Geological evidence seems to show that at the time the marsupials were most widely distributed and most abundant, the present continent of Australia was connected with Asia by a series of islands. The carnivorous and hoofed mammals had not been evolved, so that the marsupials spread over all the available land, and, subsequently, through geological changes, Australia became separated as at present. In the large land masses of North America, Europe, Asia, and part of Africa, the evolution of mammals went on, and the higher types were there gradually produced, and in the course of time entirely exterminated the weaker marsupials, who were not able to defend themselves. In the small continent of Australia, that seemed to be exactly suited to the life of the marsupials, they continued to increase without any material change, and none of the higher forms of the continents of the north were able to get into that country, owing to the separation by water; so that the marsupials have persisted in the continent of Australia (to the exclusion of all other mammalia) until the present day.

Of course, the varied round of Australia's experience gave opportunity for all sorts of animal life to develop. There are some marsupials resembling squirrels, some dogs, others resembling moles, and almost all types of mammalian life that have been developed in the north from a much higher stock have been developed from this old marsupial stock existing in Australia. In Australia, too, we find various groups of birds, such as the emus and cassowaries, representing one of the primitive groups still persisting in South America and in Africa. Geology indicates that South America was also separated and subsequently joined again by the Isthmus of Panama, so it is probable the American ostrich persisted in South America during the time it was cut off from the north, and that is the reason we still find a few species of these ostrich-like birds in the South American continent to-day.

That will show, in a general way, the manners in which these various groups of animals succeed one another in the earth's history; and in such a land as Australia we find many of these old forms persisting. Fossil specimens show they were once abundant all over the lands further north, where they have been superseded by other more highly developed animals.

The glacial epoch occurred far back in history—long before the advent of our present forms of animals upon the earth, but at a time when the earth was well populated with mammals and birds and other members of

* Lecture by Prof. Witmer Stone, of the Academy of Natural Sciences, Philadelphia. Delivered at the Academy. Specially reported for the SCIENTIFIC AMERICAN SUPPLEMENT.

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the classes we still have in abundance. Prior to the glacial epoch the temperature of the earth was hot to a point very much further north than it is to-day, so that remains of large animals, such as the mammoth and allied forms, occur away up in the Arctic regions, embedded in the ice, and various fossil remains show that numbers of tropical animals ranged far north in regions entirely too cold now for them to inhabit. When the whole northern portion of the earth was embedded in these ice caps all these animals were naturally driven to the south. As the ice and the cold temperature increased, the animals gradually crowded down toward the tropics, and, through the crowding, the weaker forms became exterminated. When the ice began to melt and retreated toward the North Pole, various of these forms spread northward again to occupy the lands that were free from the ice and again made habitable. This, of course, caused great changes in the distribution of animals. Besides the extermination of various kinds of animals, it affected the actual habitat of various others. For instance, some of the mammals that formerly lived far north and were driven southward by this ice age, subsequently, when the ice retreated through melting, followed the ice northward to somewhere near the old habitat; others, however, ascended the slope of mountains and inhabited high peaks to take advantage of the lower temperatures. Around the summits of the mountains we find to-day perpetual ice and snow, such as we find in the Arctic region at sea level; and some of the ancestors of the various birds that we find at the summit of these snow-capped mountains were originally driven south by this glacial age, and then, instead of retreating northward, they ascended the mountains to find the temperature best suited to their habits of life. Among all the mountain chains which lie within the region affected by the glacial period we find the fauna at the summit of the mountain entirely different from that at the base. On the contrary, in mountains far within the tropics—too far southward to be materially affected by the glacial period—we find that the animals inhabiting the tops of the mountains were, nevertheless, quite closely allied to those at the base, and do not represent different forms as in the mountains of the temperate regions.

Another interesting feature of the glacial age was the origin of bird migration. Previous to that time there was probably no regular north and south movement of the birds all over the world. In the tropical parts of the country to-day the birds never travel any great distance from their birthplace. Of course, there is a certain migration during the dry season to a section of the country where the food supply is more abundant—more an irregular wandering than a regular migration; but in the temperate regions the majority of them leave us on the approach of winter and return on the approach of spring.

On islands that have been at one time connected with the mainland, as Australia, the fauna of to-day, although they may be quite different from those of the near-by mainland, have evidently been derived from the forms found in a fossil condition on the mainland; and not infrequently some few forms that still persist on the mainland were very abundant on the island. In the case of islands which never did connect with the adjacent mainland (such as coral islands and volcanic islands, which have been suddenly raised from the ocean without any land connection between them and the nearest continent), we find there either no higher life at all or else modified examples of forms of animals which are found abundantly on the adjacent continents. The first form of life to appear on the volcanic islands, apart from the marine animals, will be the vegetable growth, various seeds washed by the ocean currents, stranded on the beach and soon taking root, developing a flora almost identical with that on the near-by continent's shores. In the case of a few insects, their eggs are carried in trees or mats of grass that may be washed about in the ocean currents. Sometimes on large trees we find small reptiles and mammals transported from the mainland, especially if the distance be not too great. In the case of birds, which are rather more likely to be found than either mammals or reptiles, they of course have been blown there by the storm. While it is generally supposed that birds, having the power of flight, fly over a considerable water area without any particular inconvenience, they are more or less resident and do not fly about very far from their immediate birthplace.

In the West India Islands we find a peculiar species of bird on nearly every island; although, on the series of smaller islands (the Lesser Antilles), one island is within sight of the next one, within easy range for flight. Of course the migratory birds of North America fly that whole distance, passing from one of these islands to the next; but in the case of the resident, tropical birds breeding there, they remain strictly on the island on which they belong and very rarely move from one to the other.

Some of the most interesting of these isolated islands are the Sandwich Islands, in the Pacific, and the Galapagos, on the northwestern coast of South America. In the case of the Galapagos, the most remarkable animal is the giant tortoise. It is hard to tell its origin. There being no animals of any kind developed on these islands, to kill off these tortoises, they have had an excellent opportunity to develop to a very large size without endangering their life; so we find them three feet long and a foot and a half high; and on each one of the Galapagos we find a little different variety. It is comparatively a small matter, taking account of the ages they have lived there; but the differences we find in the tortoises of each island show that they have not been distributed from one island to the other to any great extent.

In the birds of the Galapagos, the groups are found entirely different from those found anywhere else in the world. They bear a slight resemblance to those in South America (the grosbeaks), but difference in climate and food has developed an entirely different type of bird and these birds have been blown from one island to the other; so that in almost all these islands we find entirely different birds, each island having a peculiar form, although all are closely allied.

On the Sandwich Islands there are no reptiles at all, no mammals, and to-day, perhaps, no true bird; but some fifty years ago there were quite a number of birds, and, like those of the Galapagos, they were altogether peculiar, different from those found anywhere else. Strange to say, all the birds of the Sandwich Islands have been developed with the bill spatula-shaped at the end. Every one of the Sandwich Island birds is characterized by a greater or less development of that bill: that is, all except one hawk, and an owl, and a few water birds: all the small song birds. Just why this development should have occurred it is impossible, of course, to say. These Sandwich Island birds show very clearly that they have been developed from the group of honey-suckers or allied family found in the islands to the northeast of Australia. Going across the Pacific in that direction, we find that this group of islands reaches almost up to the Sandwich Islands, although rather more isolated than any of the others.

I have gone over some of the principal facts that have tended to modify the distribution of life on the earth during past geological time. Now we have to consider the present distribution of animals resulting from these various causes; and, also, to consider the present causes which are at work to effect the distribution of animals and to cause variations in their form and color.

I have already mentioned Australia as very peculiar, being inhabited entirely by marsupials; but the ice region of the north divided the land of the earth into two main sections—the eastern and the western continent. Animals adapted to life in the cold regions can very readily be found on both of these continents, while animals living only in the tropics are frequently shut off from one another. It would be impossible for them to travel from the southern part of America and around by land into tropical Asia or Africa, because it is impossible for them to live in the Arctic regions; so that we find a great number of species of animals, both birds and mammals, in northern Europe and northern America that are very similar. They may not be exactly the same species, they may be close varieties of species or may be distinct species, but belonging to the same genus or group.

All over the northern part of America are various spotted thrushes, such as our hermit thrush, the wood robin, brown-backed thrushes, with white breasts with round black spots. All over northern Europe and Asia are very closely allied thrushes, of which the English song-sparrow is the type. They are of the same general coloration, with white breasts and black spots. In the case of the shore birds, which inhabit the temperate regions of both sides of the Atlantic and which fly sometimes along the Arctic shore, we find a slight differentiation, but less than in the thrushes. Examine the common herring gull of our coast and the herring gull of Europe: the American bird is larger, with a slight difference in diffusion of color. Our grizzly bear is almost exactly like the large bear in the north of Europe; but the skulls and hair differentiate them into distinct varieties, if not the same species; and almost all our common animals of North America may be separated as distinct varieties from the species of northern Europe, although in our own country we recognize them as being quite similar.

Among the tropical animals of America and the Old World, there is not a single humming bird found in the world outside of South America and the tropical portions of North America, with the exception of one or two which straggle northward as far as Canada, one along the Pacific coast, and our common humming bird in the East; but they have evidently been derived from the tropical stock as the headquarters of the family. In Africa and Asia there are no humming birds whatever. In tropical America we find toucans, a peculiar family of birds with immense bills, generally with saw-shaped edges where the mandibles come together. There is not a single toucan found anywhere outside of South America and southern Mexico. On the other hand, we find in tropical America a family of large-billed birds of different habits and different shaped bills, known as the hornbills: they are entirely restricted to Africa and tropical Asia, and also the starling. They are found nowhere but in the old world, so that we can at once separate out this group of animals which are found in the temperate region—the temperate region comprising the northern parts of both the eastern and western continent—into one section, and the tropical regions of the eastern and western as two distinct sections.

Considering things in detail, however, we find that there are several more distinct areas than in the tropical parts of the eastern and western continents. Just around about the North Pole, as far down as the barren land, extending down to the northern limit of the tree, we have the walrus, polar bear and musk-ox; and, among birds, the Iceland falcon, the snow-bunting, and some of the northern red-poll, also the wax-wing. We find those birds and animals nowhere south of the Arctic Ocean, except in occasional migrations in extremely cold weather. Below the Arctic region, covering the north temperate region both of Europe and Asia, we find what is known as the North American Temperate Realm. That extends as far south as the isotherm of 70° Fahrenheit. Below that we have in America what is known as the American Tropical Realm. The North American Temperate Realm is characterized by a species of crows; among animals, the majority of the common kinds of deer; the caribou or reindeer; the elk—the vast majority of the true deer with permanent horns. Then this American Tropical Realm is characterized by humming birds, the toucans, the tanagers and motmots and all the characteristic birds of North and South America and Brazil and the other countries. In the American Tropical Region are vast numbers of parrots and monkeys. The American Tropical Realm is particularly interesting, because they are also found in the tropical regions of the old world and seem to afford exceptions to the instances I mention; but it seems as if the parrots and monkeys and some other types were distributed in the same way as the marsupials; that is, they reached South America at very ancient times and have been comparatively little modified up to the present day. The fossil remains are found in the regions of the north, showing they were once spread all over the North American and European continents, but at the time of the glacial epoch, perhaps, they were exterminated entirely from those areas; persisted in large numbers on both sides of the Atlantic; and have been comparatively little modified. We can separate at once the monkeys of the old world from those of the new world, and in the same way the parrots; but any one could recognize the animals of the two continents as monkeys and parrots.

The tropics of the old world correspond to the American Tropical Realm—including all of tropical Africa south of the desert of Sahara and all of tropical Asia south of the Himalaya Mountains, which form a kind of steppe, a high elevated plateau, covering Siberia and the northern part of Asia and culminating on the south with the Himalaya range; and then the southern slope of the Himalaya leaps right down into the tropical region and south. All through India, Siam, and those countries, we have a strictly tropical type and everywhere the mountains serving as a barrier.

The southern part of South America, from the southern edge of Brazil south to Patagonia, is entirely outside of the Tropical Realm and is the Southern Temperate Region. There are quite a number of peculiar birds and animals inhabiting this region which have been evidently derived from the same stock as the American Tropical Form, but modified by the cooler temperature.

Then we have the region of Australia and also the island of Madagascar, which constitutes a distinct zoological region, inhabited by those peculiar apes known as the lemur and by various peculiar types of birds not found elsewhere. Madagascar and some small groups of islands to the eastward represent a large continent which disappeared to a great extent.

We have, then, these seven areas: the Arctic; the North Temperate; the American Tropical; the Indo-African or Old World Tropical; the South American Temperate Region; the Australian Region; the Madagascar Region. The only remaining portion of the world not included is the Antarctic Continent, that is characterized by a total absence of all sorts of life, except some of the marine forms and a few penguins.

In Pennsylvania, between the Blue Ridge and the Alleghenies practically, the area is covered by a series of mountains of greater or less elevation than in the northeastern corner; in Wayne and Susquehanna Counties is a high table-land which enters our State from New York, and is really a southwestern extremity of the Catskill Mountain plateau. All the western portion of Pennsylvania is covered by this table-land, which slopes off from the Allegheny Mountains to the westward. All that region is included in the Canadian or Boreal Region; it covers all the Alleghenies in Pennsylvania. That area was at one time entirely covered by hemlock and spruce forests, and various birds affected it in the winter time and were very abundant summer residents. At present the lumbering business has been carried on to such an extent that the majority of them are almost exterminated, except in two or three tracts where the hemlock forest is still allowed to stand. The most famous of these is about the region of the North Mountain, north of Wilkesbarre and northwest of Williamsport, including the region about Harvey's Lake and various others of the lakes found in that part of the mountains. There are still whole spruce and hemlock forests, extending over many miles, in that area, although the lumbermen are making inroads among them on all sides, and it seems only a question of time when these forests will disappear, and with them the majority of our northern birds. In the month of June we find the snow-birds, winter wren, brown creepers, the white-throated sparrows and quite a number of our warblers—birds we are familiar with about Philadelphia only in the winter time, as transient visitors, and we recognize immediately the wonderful difference in the bird forms the minute we enter this area; all the birds we are familiar with in autumn, with few exceptions, have disappeared. Of course, such birds as the robin travel wherever there is the slightest sign of habitation. The sparrows are even more persistent; it is impossible to get rid of them, but the meadow-larks and various species which are characteristic of the open fields disappear entirely when we enter these cool hemlock forest regions. The actual temperature on our Allegheny Mountains in the summer time is not materially different from what we experience at the lower levels. Of course, it is much cooler at night, but the elevation is not sufficient to make any wonderful difference in the temperature. It seems surprising that such a slight difference in the climate should have such an effect on the distribution of birds.

This effect of climate seems to be the entire secret of the distribution of birds and mammals at least, and, of course, the balance also—indirectly—of all the forms of life. It seems that the average temperature of a certain locality taken during the year affects the animals that are living there. An animal cannot live satisfactorily in an area unless the temperature is of a certain average—one form being adapted to one climate and another to another; and small gradations of climate that do not seem to affect the animal at all seem to greatly affect its distribution. On the mountains of southern Mexico we can actually see on the side of the mountain the lower limit of the pine and hemlock tree, and below this the deciduous trees sloping down to the valley. You can see, in a region of less than a mile extent, the two areas—one inhabited by one class of birds, the other by the other; and yet the birds never mix to any extent. They seem to be governed entirely by the climate and the general surroundings of vegetation, which, of course, is directly dependent on climate, so that it seems as if climate controlled the distribution of animals more than anything else.

Some of the higher mountains in New Jersey have strong evidences of the Canadian fauna; and it is very interesting, as we go further south in the United States, to see the isolated peaks of mountains that show evidences of this Canadian or northern fauna, which extends all the way down the Middle Alleghenies, as far as Virginia (though the lower mountains of southern Virginia do not seem to be so strongly characterized by these northern birds); while in North and South Carolina the Canadian fauna again crops out on the tops of the high peaks.

Our northwest coast and the Great Plains are peculiarly interesting on account of the effect that they have on all the animals inhabiting them. The plains being devoid of trees and exposed to the sun, the animals are all more or less bleached; and in the Great Basin, especially the lower parts, abounding in these dry, arid tracts, the animals are very much bleached and very differently colored from those inhabiting the other areas. On the northwest coast exactly the contrary occurs; for all the area is thoroughly wooded and has the heaviest rainfall to be found anywhere in the

United States, and the animals there are very much darker in color.

The common ground-squirrel or chipmunk found about Philadelphia has a decidedly reddish tint on the back. Now to the Northwest Coast, Washington and Oregon, see the chipmunk! The general color markings are all precisely the same; but the dark color is very manifest. Take the fox squirrel breeding in the northern section of the eastern country; they are rusty-coated. The fox species is distributed over the country, and when we get them from the Northwest Coast we find them exceedingly dark. The general character is exactly the same; but they are dark, exactly the difference between the two chipmunks. The song sparrows from the two extremes show exactly the same thing; these from the eastern area lighter, and these from the western area darker. In the case of the brown thrasher which we have in the east we see the same general tone of coloration as found in the chipmunk. Unfortunately, it is not found in the Northwest. Take some of the birds and mammals from the southern part of the Canadian Region; from California and from the southern part of our Great Basin Region, the region of the alkali deserts; take the thrashers again, they are found abundantly there; note the modification of the thrashers of the southern part of the Canadian Region from our thrashers of the East. Out on the desert see what the sunshine and the desert environment does for the thrasher, it turns almost white. Now consider one of the song sparrows, the same area, inhabiting the southern part of the California Regions. The song sparrows are almost the same as our eastern birds. The one from the desert we find bleached almost as much as the thrasher.

Among the mammals, they have some in California, the jumping rat, of which we have a couple of specimens here; the general color is dark brown; as they get out on the deserts the jumping rats are almost white, almost exactly resembling the alkali ground; and at a short distance it is almost impossible to distinguish them. Of course the peculiar coloration in them becomes a protective device; but it seems to result largely from the peculiar environment of that area.

It is quite possible for the zoologist to predict what form of mammal to expect, if you hear of a group form found in any particular area. If it is found from a desert area, it is possible to write an accurate description of it without ever having seen it.

I have said nothing of the distribution of marine forms, or fresh water animals, because that is not so interesting a topic and is not so well known. The distribution of fish and aquatic reptiles and batrachians does not follow the same rules as in the case of land animals. In that case we find the fish of one river system differ from those of another without regard to the country through which the river system passes. For instance, in a certain mountain range, like the Allegheny Plateau, we find that the fish found in a branch of the Susquehanna are usually allied in form to one group, while those of the little streams that start off on the western slope of the plateau and empty into the Ohio belong to another, and sometimes the little streams or branches of these come within a mile or one-half mile, and we will find one style of fish in one and another style in the other, without any regard to the geological position of the land; so that the distribution of water forms is entirely different and due to somewhat different causes than the temperature of the water and does not follow the same rules as the case of the distribution of the land animals.

In the case of the marine forms, we find that in the ocean itself, the distribution is largely one of depth. We find the deep sea fishes entirely different in character from those at the surface, or median depths; at the same time, the distribution of marine forms serves very well to help out the history of the land forms. For instance, we have a good deal of evidence that at one time North and South America were separate; the Isthmus of Panama was broken through, and we find among the marine forms along the eastern coast and those along the western coast sometimes exactly the same species and quite frequently the same genera, which is very strong evidence that at one time there was water communication across there which is now shut off. If the land had persisted there at all times, there would have been very little possibility of the same form of fishes being abundant on both sides.

The Atchison, Topeka & Santa Fe Railway is, in an experimental way, to shortly enter the automobile field. It has been decided to make a trial of gasoline motor-propelled omnibuses in the transportation of tourists from Flagstaff, Ariz., to the Grand Canyon of the Colorado River, a distance of 70 miles. At present this trip is taken by stage coach, which is exceedingly tiresome at best. The first of the vehicles, which is now being built by the Everett-King Company, Chicago, is to be delivered to the railway company for trial in a few weeks. It is expected to make the trip of 70 miles at an average speed of 12 miles an hour for the entire distance. The power to accomplish this is obtained from a 14 horse power gasoline motor, which is of the two cylinder balanced type. The car has a capacity of 18 persons, 12 inside and 6 outside. Should the use of the automobiles prove a successful experiment in this service, they will probably be used at other places to reach the scenic attractions now difficult of access along the line of the Santa Fe.

Although there are several instances on record of mending a broken shaft at sea, there is none on record, at least, of making a new propeller. Yet that, says The Marine Journal, is what the chief engineer of the steamer "Strathnevis" had nearly accomplished when she was taken in tow after having been a month helplessly adrift on the Pacific. This propeller was constructed by heating iron sheets, cutting them to the right measurements and hammering them into the proper shape. It had a length from tip to tip of 7 feet 6 inches, and by bolting the sheets together he obtained a thickness of from ¼ inch at the tip to 3 inches at the boss. Straps were bolted from tip to tip to hold the blades rigid and holes were bored through the boss. Had any favorable weather occurred, it was the intention to shift the cargo sufficiently to tip the ship and bolt this ingenious contrivance to the shaft, and there is no doubt but that its use would have given the ship a speed of from 3 to 5 knots.

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